NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF THE ENDWALL FLOW IN A CASCADE OF COMPRESSOR BLADES

by

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September 2000

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REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
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1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** September 2000	**3. REPORT TYPE AND DATES COVERED** Master's Thesis	
4. TITLE AND SUBTITLE: Experimental and Computational Investigation of the Endwall Flow in a Cascade of Compressor Blades			**5. FUNDING NUMBERS**
6. AUTHOR(S) Carlson II, James R.			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.			**12b. DISTRIBUTION CODE**

13. ABSTRACT *(maximum 200 words)*

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Overall, good correlation between the five-hole probe and LDV measurement techniques was obtained; however, the CFD predictions did not match well with the experimental results, particularly at the midspan location of the blade where separation of the suction surface boundary layer occurred.

14. SUBJECT TERMS laser Doppler velocimetry, controlled-diffusion compressor blading			**15. NUMBER OF PAGES** 126
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF THE ENDWALL FLOW IN A CASCADE OF COMPRESSOR BLADES

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

An investigation of the three-dimensional flow in a cascade of second-generation controlled-diffusion blades, which was as a result of the interaction of the endwall boundary layers with the blade profiles, is reported. Five-hole probe wake surveys were performed at various spanwise locations to determine the total pressure loss distribution. Downstream velocity vector information was also obtained from the five-hole probe surveys. Two-component laser-Doppler velocimetry (LDV) was used to characterize the flow in the inlet and wake regions. A numerical investigation of the flowfield was conducted using SWIFT, a computational fluid dynamics code developed by Dr. Roderick Chima of NASA Glenn Research Center. Experimental blade-surface pressure coefficients were compared with values predicted using SWIFT.

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I. INTRODUCTION

A. BACKGROUND

The requirement for smaller and more powerful gas turbine engines to meet the demands of today's aircraft has led to increased blade loading, improved performance at the design point and the ability to operate at off-design conditions without compressor stall. The problems of compressor stall and off-design behavior have long been the limiting factors in the performance of these engines. This has led to the development of Controlled-Diffusion (CD) blading.

Controlled-Diffusion blades are profiles specifically designed to produce the desired pressure distribution, whilst avoiding boundary-layer separation on the suction side of the blade. This allows higher blade loading or, equivalently, more turning for each blade row. The result is to require fewer blades to obtain the desired pressure ratio within a compressor stage, or to obtain a higher-pressure ratio per stage with the same number of blades. Furthermore, compressor size and weight will be reduced for a given engine thrust.

Controlled-Diffusion blading was made possible by the development of Computational Fluid Dynamics (CFD) techniques. Since CFD is an integral part of the blade design process, validation data must be gathered in order to continue the development of more efficient, higher performance blading.

The present study was an investigation of flow through CD compressor blades in the Naval Postgraduate School (NPS) low-speed cascade wind tunnel (LSCWT). The blades and cascade geometry modeled the midspan Stator 67B section, designed by Thomas F. Gelder of NASA Lewis Research Center [Ref. 1]. The current airfoils are second-generation blades developed as an improvement over Stator 67A, a first generation CD blade row designed by Nelson Sanger [Ref. 2]. The current blades, together with Rotor 67, comprise Compressor Stage 67B, which was experimentally tested by Gelder et. al. [Ref. 1]. Hansen [Ref. 3] examined the flow through the midspan section at a near-design inlet-flow angle of 36.3°, using Laser-Doppler Velocimetry

(LDV) and pressure probe measurements. Schnorenberg [Ref. 4] studied the off-design flow characteristics at an angle of 38°. LDV measurements, flow visualization, and blade surface pressure measurements were used to investigate the effect of Reynolds number on a separation region detected near midchord. Grove [Ref. 5] characterized the flow patterns at an inlet flow angle of 39.5°. Flow visualization, rake probe surveys, blade surface pressure measurements and LDV measurements were used to document the flow upstream, in the passages between the blades, in the boundary layer of the blades, and in the wake region. Nicholls [Ref. 6] characterized and compared the flow patterns over and around the blades after the replacement of the tunnel motor. The inlet flow angle was found to have increased from 39.5° to 40° with no movement of the blades in the tunnel.

B. PURPOSE

The objective of the current study was the characterization of the three-dimensional flow behavior in the endwall region of the cascade. Five-hole probe measurements and two-component LDV measurements were used to characterize the flow upstream of the blades and in the wake region of the blades at a Reynolds number of 640,000. The main purpose for experimentally measuring the complex endwall flow field was to generate a data set for comparison with future CFD predictions. Toward that goal, CFD studies were initiated to compare blade surface pressure distributions at various inlet flow angles and inlet boundary layer thickness.

II. TEST FACILITY AND INSTRUMENTATION

A. LOW-SPEED CASCADE WIND TUNNEL

The present study was conducted in the Low-Speed Cascade Wind Tunnel located at the Naval Postgraduate School's Turbopropulsion Laboratory. A schematic of the cascade in the Low Speed Turbomachinery Building is shown in Fig.1. All aspects of the tunnel remain as previously documented by Nicholls [Ref. 6].

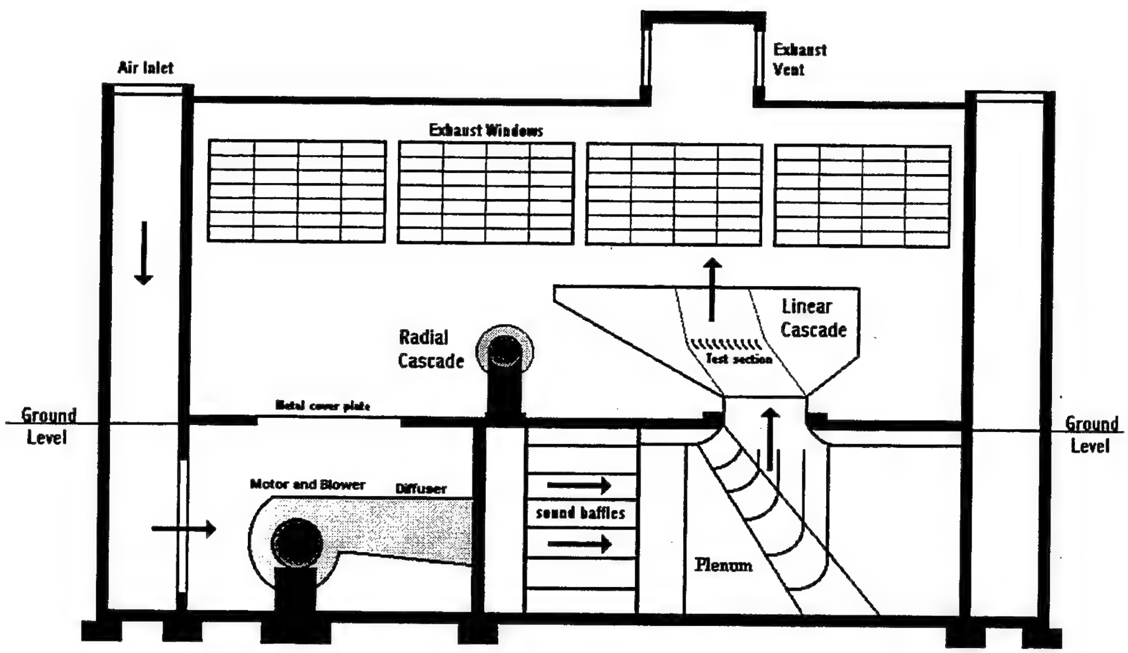

Figure 1. NPS Low-Speed Cascade Wind Tunnel [From Ref. 6]

B. TEST SECTION

The test section of the LSCWT contained 10 Stator 67B controlled-diffusion blades. The installation of the blades in the test section was detailed by Hansen [Ref. 3]. A detailed layout of the test section is shown in Fig. 2. Prior to the current study, the blades were tested at the near-design inlet angle of 36.3° by Hansen [Ref. 3], at 38° by Schnorenberg [Ref. 4], at 39.5° by Grove [Ref. 5], and at 40° by Nicholls [Ref. 6]. The test section configuration was identical to that reported by Nicholls.

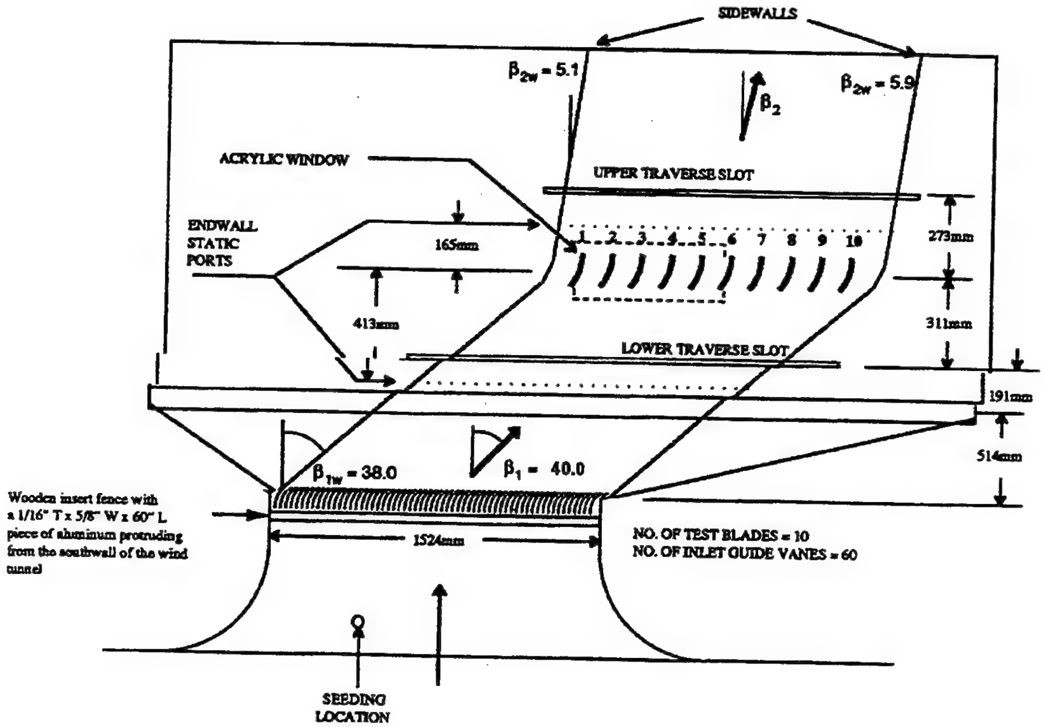

Figure 2. Test Section Schematic [From Ref. 6]

The blades were scaled from the midspan section of Stator 67B [Ref. 1]. The coordinates used to machine the blades were documented in Reference 3. Each blade was 254 mm in span, 127.25 mm in chord, and set with a blade spacing of 152.4 mm.

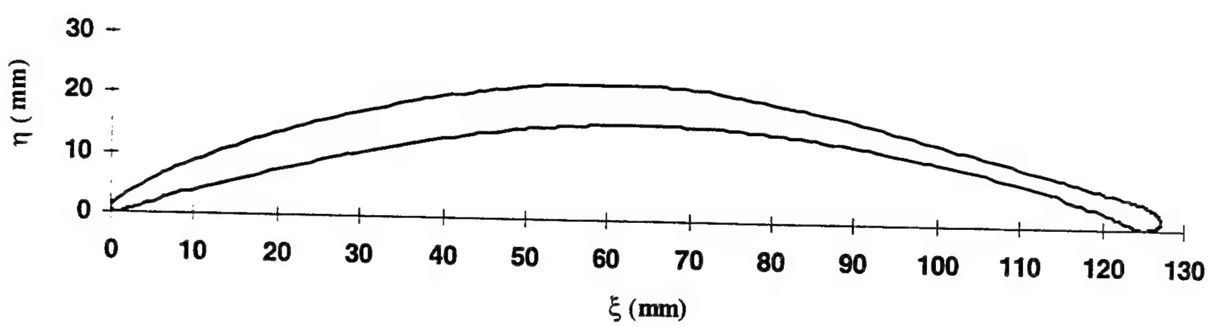

Figure 3. Blade Profile [From Ref. 6]

The blade profile is shown in Fig. 3. Blades 2 and 8 were partially instrumented with eight pressure taps, and blade 6 was a fully instrumented blade containing 42 pressure taps.

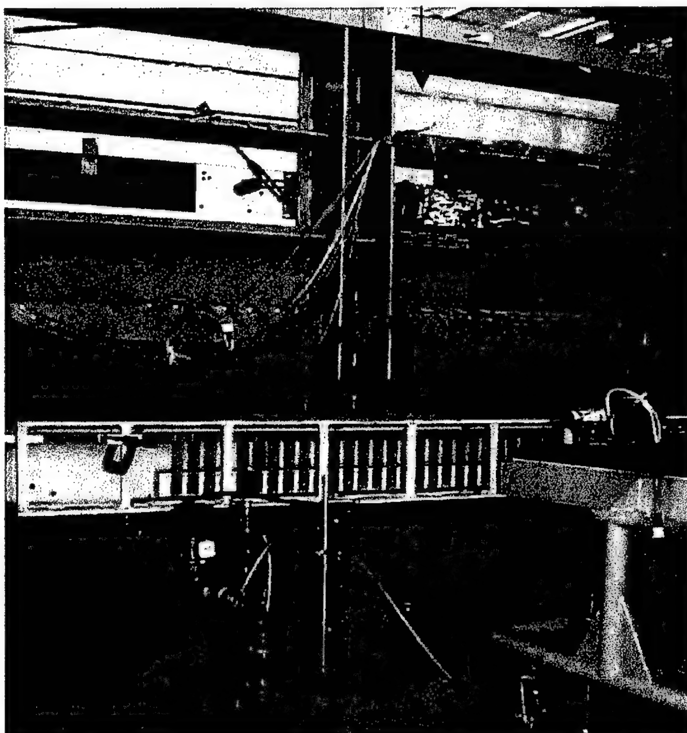

Figure 4. Tunnel Overview

Five-hole probe measurements were conducted in the wake across blades 3 and 4. These surveys were conducted in the upper traverse slot (Fig. 2) approximately two chord lengths downstream of the blade trailing edge. LDV measurements were conducted both upstream and downstream of the test section primarily around blades 3 and 4. The area between these blades was anodized black to minimize laser light backscatter. Figure 4 shows the five-hole probe, LDV probe, LDV traverse mechanism, seeding apparatus, and LDV seeding locations.

C. INSTRUMENTATION AND DATA ACQUISITION

1. Pressure Surveys

Pressure surveys were carried out to characterize the flow in the wake of the blades. Surveys were completed from centerline to the endwall region to acquire the pitchwise and spanwise distribution of the coefficient of stagnation pressure similar to those of the rake probe survey. This provided a map of the flowfield over which two-dimensional LDV surveys would be conducted.

a. Pressure Measurements

The wake pressure surveys were carried out using a five-hole pressure probe traversing from the leading edge of blade 3 across to the trailing edge of blade 4. The probe used was a United Sensor conical five-hole probe with a probe diameter of 3.0 mm and port-hole size of 0.1 mm (Fig. 5).

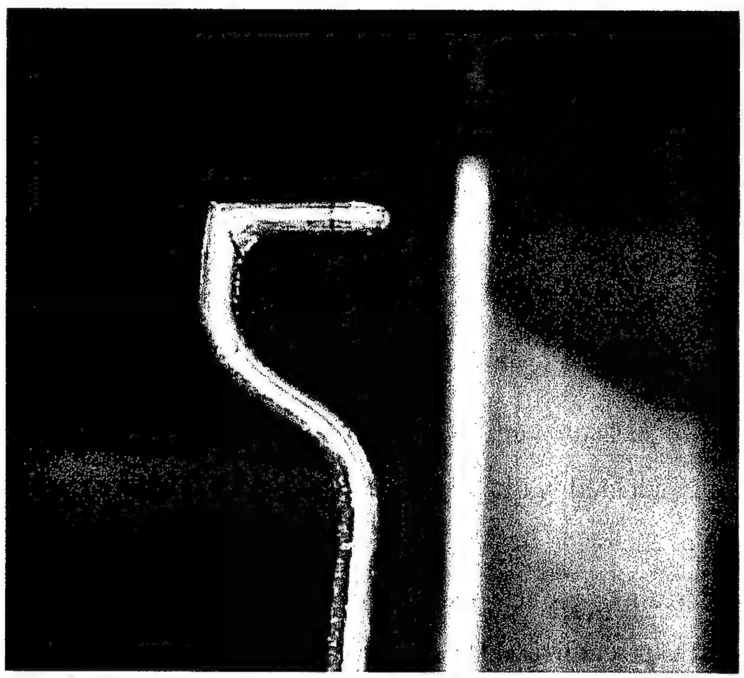

Figure 5. United Sensor Conical Five-Hole Probe

This probe was used as a non null-yawed probe and did not require null yawing at each position before recording the pressure measurements. The students of AA3802 Fall 2000 class calibrated this probe as their term project. Reference 7 outlines

the probe calibration and functional limitations (Mach number, pitch and yaw angles). Matlab codes and data developed by this class to determine calibration coefficients are presented in Appendix D. The Matlab code "fhpsurveys.m" developed to analyze the nine pressure surveys taken for this study is also presented in Appendix D.

All pressures from the five-hole probe were recorded using Scanivalve #2 a 48-channel rotary pressure scanner. Scanivalve #2 ports and channel assignments were as follows:

Table 1. Scanivalve #2
Five-hole Probe Measurements

1	Atmosphere Pressure	25	Not Used
2	Calibration Pressure	26	Not Used
3	Plenum Pressure	27	Not Used
4	P Wall Static Pressure	28	Not Used
5	Port 1 Pressure	29	Not Used
6	Port 2 Pressure	30	Not Used
7	Port 3 Pressure	31	Not Used
8	Port 4 Pressure	32	Not Used
9	Port 5 Pressure	33	Not Used
10	P Prandtl Total	34	Not Used
11	P Prandtl Static	35	Not Used
12	Not Used	36	Not Used
13	Not Used	37	Not Used
14	Not Used	38	Not Used
15	Not Used	39	Not Used
16	Not Used	40	Not Used
17	Not Used	41	Not Used
18	Not Used	42	Not Used
19	Not Used	43	Not Used
20	Not Used	44	Not Used
21	Not Used	45	Not Used
22	Not Used	46	Not Used
23	Not Used	47	Not Used
24	Not Used	48	Not Used

b. Data Acquisition

All pressure data were acquired using the HP75000 Series B VXI-Bus Mainframe controlled by HPVEE Software running on a personal computer. The acquisition system was documented by Grossman [Ref. 8]. The HP-VEE program

"Test_Scanners_Fivehole" used to control the Scanivalve rotary pressure scanners was developed by Nicholls and is documented in Reference 9.

2. LDV Measurements

LDV measurements were obtained using a TSI two-component fiber-optic system. The system included a five-Watt Lexel Model 95 argon-ion laser, directed into a TSI Model 9201 Colorburst, transmitted by fiber-optic cables to a 83 mm probe. The reflected signals were collected by the probe and fed back to a TSI Model 9230 Colorlink, via a return fiber optic cable. The laser and optics system, data acquisition system, laser flow seeding systems, and traverse mechanism, were described by Dober [Ref. 10]. All LDV data were acquired and reduced using TSI PACE software, version 1.4.

III. EXPERIMENTAL PROCEDURE

A. PRESSURE MEASUREMENTS

In order to verify that the tunnel parameters remained unchanged from Nicholls' work [Ref. 6], a centerline five-hole probe pressure survey was conducted. The tunnel was run at a plenum gage pressure of 305mm (12 inches) of H_2O, corresponding to a Reynolds number of 640,000 and a freestream Mach number of 0.22. Upon validation of the centerline data, eight additional pitchwise surveys were conducted at various span locations.

1. Five-Hole Probe Pressure Measurements

The five-hole probe was mounted in a traverse mechanism in the upper traverse slot of the tunnel (Fig. 2). The probe was initially centered at midspan of the blades and aligned with the leading edge of blade 3. The probe was traversed across two blade spaces. All spanwise surveys were taken between centerline and the north wall.

Timing between data points was determined by trial and error. A time delay was necessary in order for pressures to stabilize in the tubing back to the Scanivalve. Thirty second, one minute, two minute and three minute time intervals were tested. Waiting two minutes between moving the probe to its new position and recording of the test data achieved the desired pressure stabilization and proved to be the most efficient timing interval.

The probe was initially set head on into the flow. After several test surveys it was determined that the average yaw angle of the flow was 10° at the centerline. The probe was calibrated for a yaw range of +/- 15°. Thus to maximize the available yaw range, the probe was rotated 10° (Fig. 6). This centered the yaw measurements with respect to the range over which the probe was calibrated.

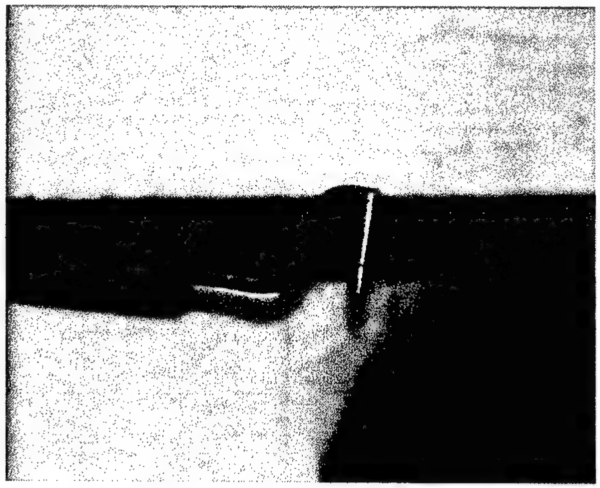

Figure 6. Probe Yawed 10°

HP-VEE data were saved to an EXCEL spreadsheet and later reduced for each survey. A total of nine five-hole pressure surveys were conducted at the following spanwise locations:

Table 2. Spanwise Survey Locations

SPANWISE LOCATION #	FRACTIONAL SPANWISE LOCATION (z/h)	DISTANCE FROM CENTERLINE (inches)
1	0.500000	0.00000
2	0.400000	1.00000
3	0.300000	2.00000
4	0.200000	3.00000
5	0.146875	3.53125
6	0.096875	4.03125
7	0.046875	4.53125
8	0.021875	4.78125
9	0.009375	4.90625

B. LDV MEASUREMENTS

1. Tunnel Calibration

Plenum pressure, plenum temperature and, atmospheric pressure were recorded, while vertical and horizontal velocity components were measured with the LDV at Station 1 (Fig. 7). The initial tunnel conditions were entered into a FORTRAN program, CALIB1.FOR, to determine the tunnel reference velocity for each survey [Ref. 3]. Each run was non-dimensionalized using the reference velocity calculated for that survey. This allowed surveys conducted under different atmospheric conditions to be compared.

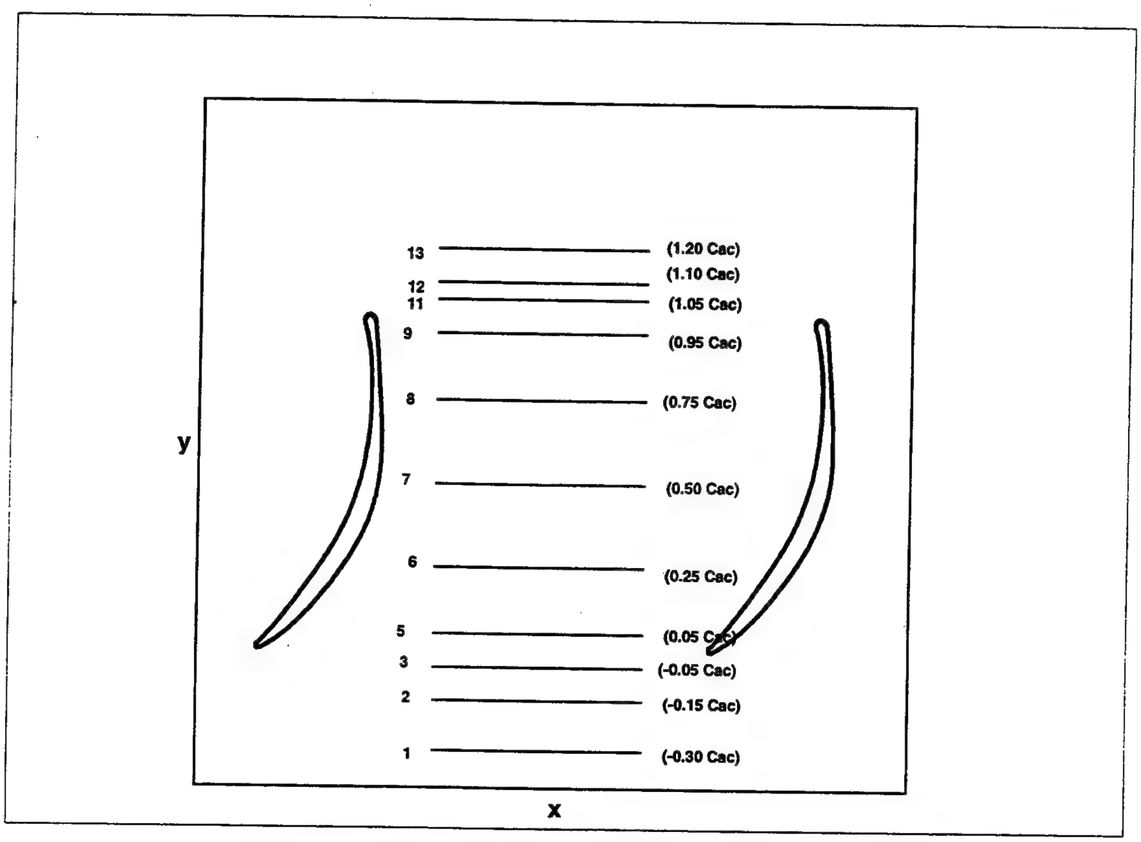

Figure 7. LDV Survey Locations [After Ref. 6]

2. Probe Volume Alignment

The LDV probe volume was aligned using an alignment tool. A description of the coordinates for the alignment tool are documented in reference 3. LDV surveys were performed at various spanwise locations beginning at mid-span, then moving in one-inch increments towards the north endwall, which was the endwall through which the LDV

surveys were conducted. These spanwise LDV survey locations corresponded to five-hole probe locations 1-4, and 6 in Table 2. All survey positions were measured from a reference position at the leading edge of blade 3.

3. Particle Seeding

Particle seeding is one of the most important issues involved in making LDV measurements. The selection of the seeding medium and the location where the seeding particles are injected into the flow are critical. The seeding particles must be the correct size, approximately one micron in diameter, in order to follow the flow, and must be able to scatter the light from the incident laser beam. The seeding location determines the area downstream in the test section that will contain enough seed particles to produce a sufficient data rate for data acquisition. The seeding source, which is usually a wand, must be located far enough upstream so that any flow field interference caused by the wand has time to mix out before the flow enters the test section [Ref. 10].

Olive oil was used as the seeding material for the LDV measurements. The same seed particle generator was used as in previous studies [Ref. 10]. Initially the seeding material was injected via a seeding wand into the flow upstream of the inlet guide vanes as shown in Fig. 2. This seeding location allowed the flow field interference to mix out and bathed the midspan of the test section with sufficient seed particles for data acquisition. The seeding wand could be rotated 360 degrees, which moved the location on the centerline where the seeding was focused. However, the spanwise depth of the wand could not be adjusted to move the seeded area off-centerline. The fixed spanwise seeding location, while excellent for centerline survey of the inlet and wake region, proved to be inadequate for off centerline surveys. The obtainable data rate off-centerline was insufficient for data acquisition.

A new seeding location for both centerline and off-centerline surveys was used by drilling access holes into the tunnel just upstream of the inlet guide vanes (Fig. 8). These access holes allowed for spanwise depth adjustment, and rotation of the seeding wand, to maximize the data rate at the desired test location. The seeding wand position was manually adjusted to center the seeding over the probe volume for each LDV data point.

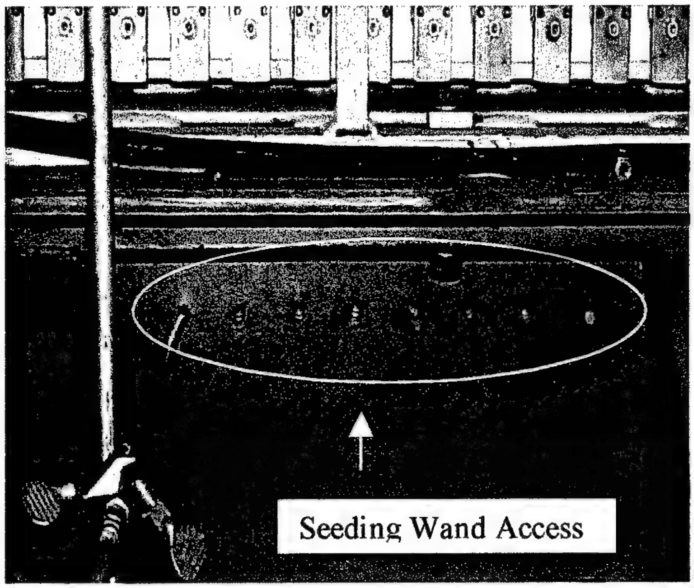

Figure 8. LDV Seeding Access Ports

4. LDV Surveys

Only two-dimensional LDV surveys were completed in the present study. The inlet flow angle remained unchanged from Nicholls at 40 degrees [Ref. 6]. These surveys were a combination of inlet and wake surveys at tunnel settings corresponding to Reynolds numbers of 640,000. The flowfields at station 1 (inlet survey) and station 13 (wake survey) were measured from centerline outward towards the endwall region, over two complete blade passages. Figure 7 shows all the pitchwise survey locations. A total of five LDV surveys were completed upstream, and four LDV surveys were completed downstream of the blades.

Data collected by the laser included axial and tangential velocities, turbulence intensities, Reynolds stresses and the Reynolds stress coefficient. A new data collection software package (PACE 1.4) was added to the test equipment for the present study. PACE 1.4 is a TSI windows-based software package specifically designed for LDV systems.

a. Inlet Surveys

Inlet flow surveys were conducted at station 1 across blades 3 and 4. 1 MHz of frequency shifting was utilized for data acquisition. All histograms used 1000 data points.

b. Wake Surveys

Wake surveys were conducted at station 13 across blades 3 and 4. 10 MHz of frequency shifting was utilized for data acquisition. All histograms used 1000 data points.

IV. RESULTS AND DISCUSSION

A. FIVE-HOLE PRESSURE PROBE MEASUREMENTS

Downstream five-hole probe surveys were taken across two blade passages at a Reynolds number of 640,000. A total of 49 data points, with a uniform spacing of 4.1667mm, were recorded during each survey. Loss coefficients and AVRs were calculated for each survey using the formulas documented in Appendix A. Pitchwise surveys were completed from the centerline to the northern endwall region (Table 2) to acquire a map of the coefficient of stagnation pressure, C_{pt2}, which is defined as the ratio of total downstream pressure ($P_1 = P_{t2}$) versus plenum pressure, similar to those of the rake probe survey presented by Nicholls [Ref. 6].

Figure 9 shows the pitchwise, non-dimensionalized pressure distribution. Figure 10 shows the non-dimensionalized velocity distribution. Figure 11 shows the pitch- and yaw- angle distributions along the centerline.

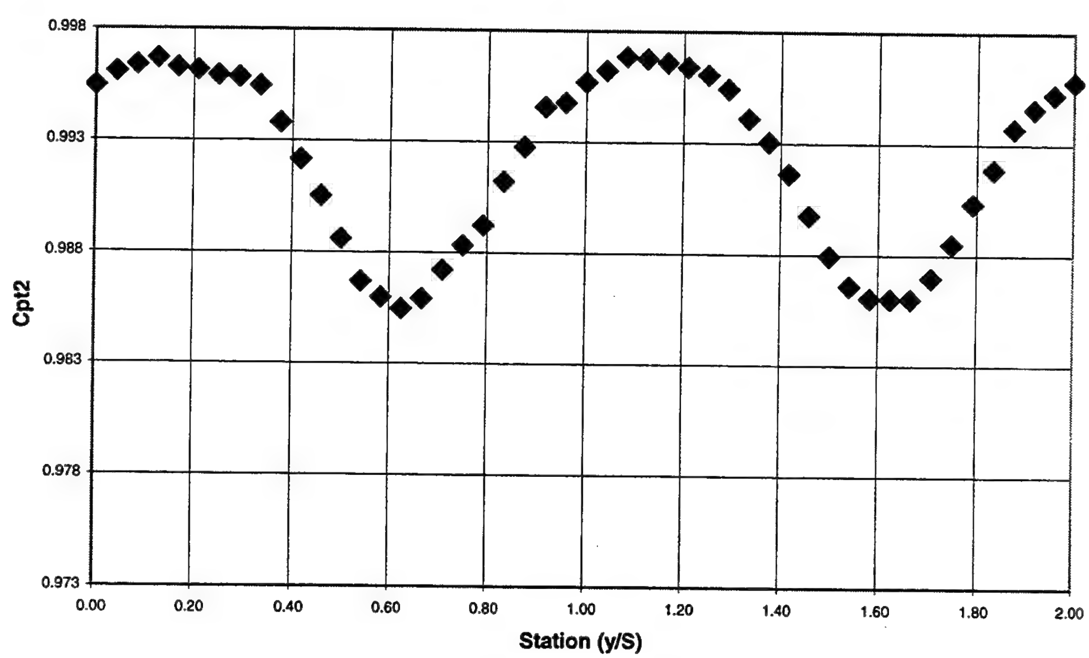

Figure 9. Centerline Non-Dimensional Pressure Distribution (Probe Location 1)

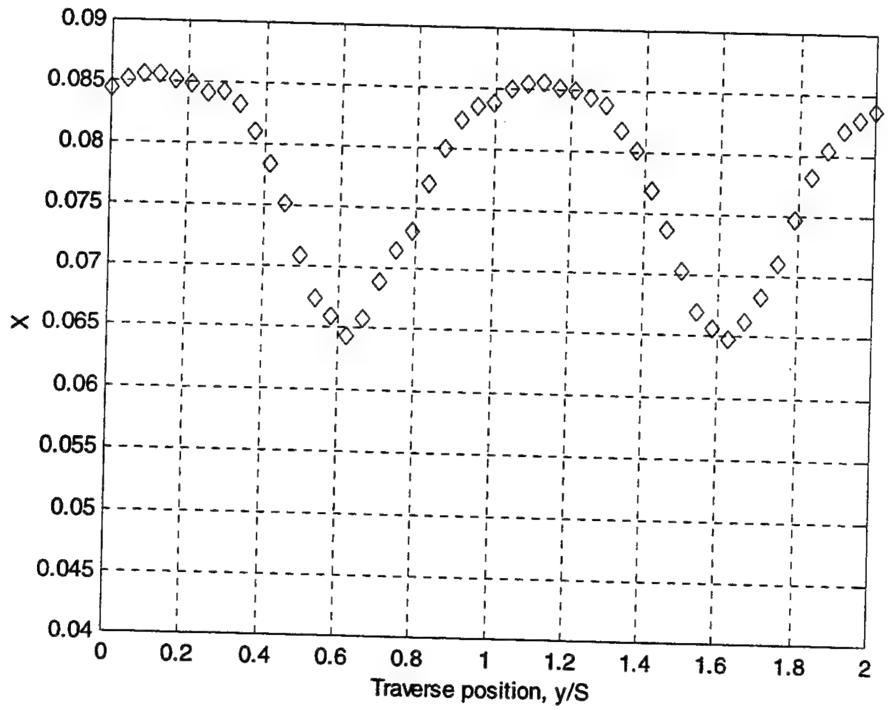

Figure 10. Centerline Non-Dimensional Velocity Distribution (Probe Location 1)

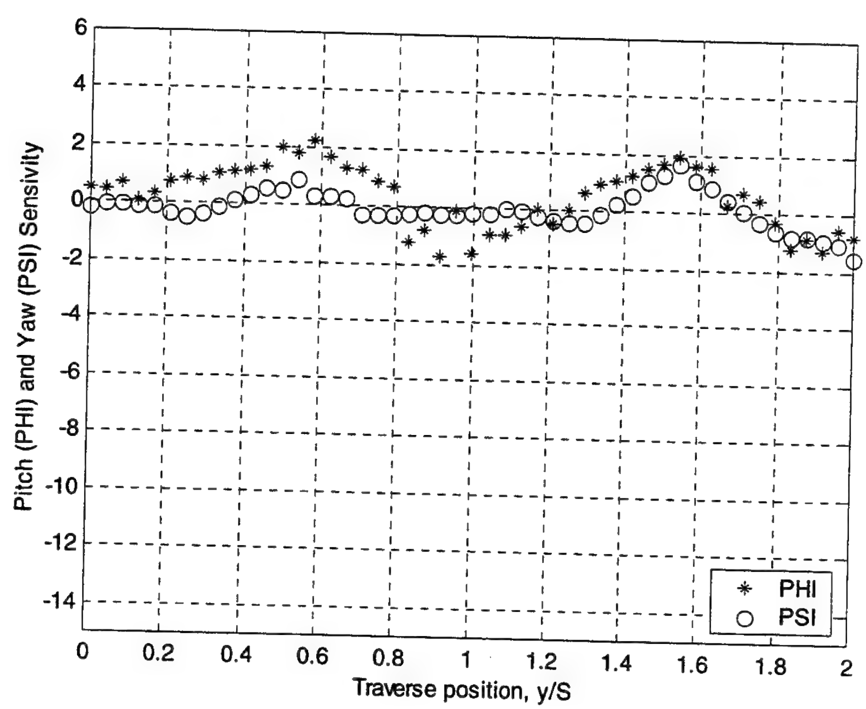

Figure 11. Centerline Pitch and Yaw Sensitivity Profile (Probe Location 1)

The loss coefficient for the centerline survey was found to be 0.12 and the AVR was 1.028, in comparison with 0.13 and 1.015 respectively obtained by Nicholls [Ref. 6]. This comparison showed that the measurements as a result of non-null yawing the probe were consistent with previous measurement practices (which was to null yaw the probe).

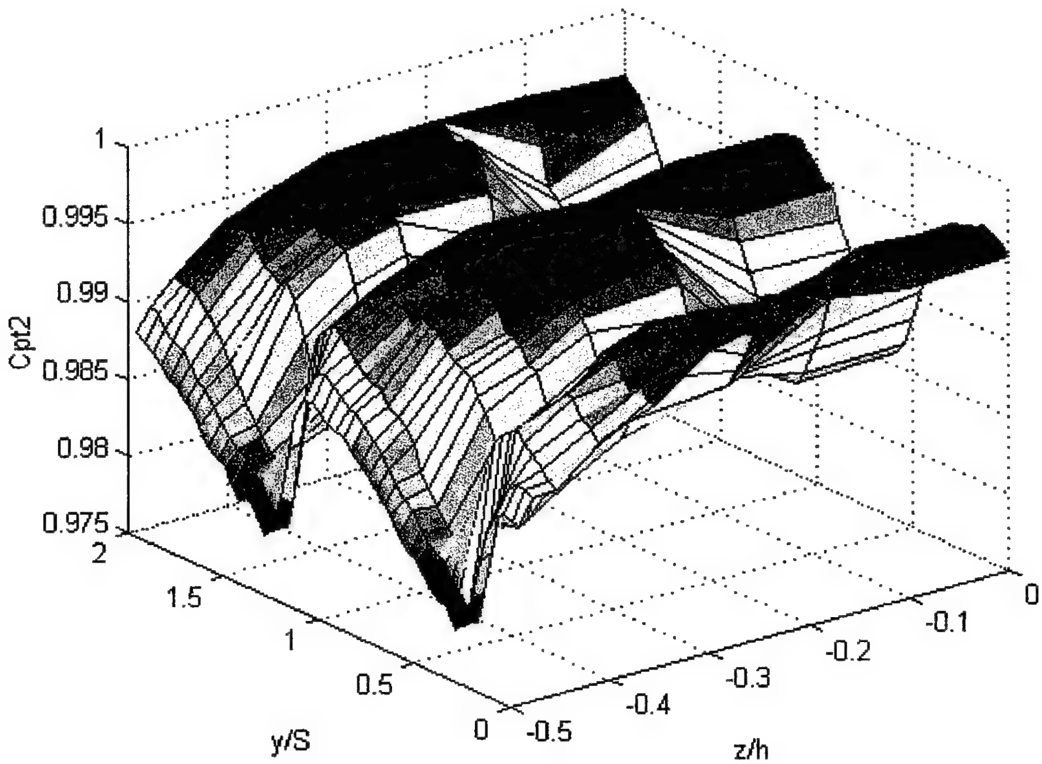

Figure 12. Summary Surface Plot of Non-Dimensional Pressure Distribution (Cpt2)

Eight additional five-hole pressure surveys were conducted over the same two blade passages but at different spanwise locations. A surface plot of the non-dimensionalized pressure (Cpt2) from centerline (z/h = 0) to the endwall region was generated and is shown in Fig.12 as a summary of all of the surveys. Individual survey plots similar to Fig. 9 through 11 for all nine five-hole probe pressure surveys are presented in Appendix B. Reduced data for all nine five-hole probe pressure surveys are presented in Appendix C. The five-hole probe data reduction in MATLAB is presented in Appendix D.

Figure 13 is a summary spanwise and pitchwise distribution plot of the non-dimensional velocity (X) and a vector plot of the secondary flow present within the wake. Data points were blanked out in the last two surveys as they were off the calibration map, i.e. X<0.04, Φ>15degrees, and Ψ>15degrees, even though the probe was yawed 10degrees to bring the mean flow angle close to zero at centerline.

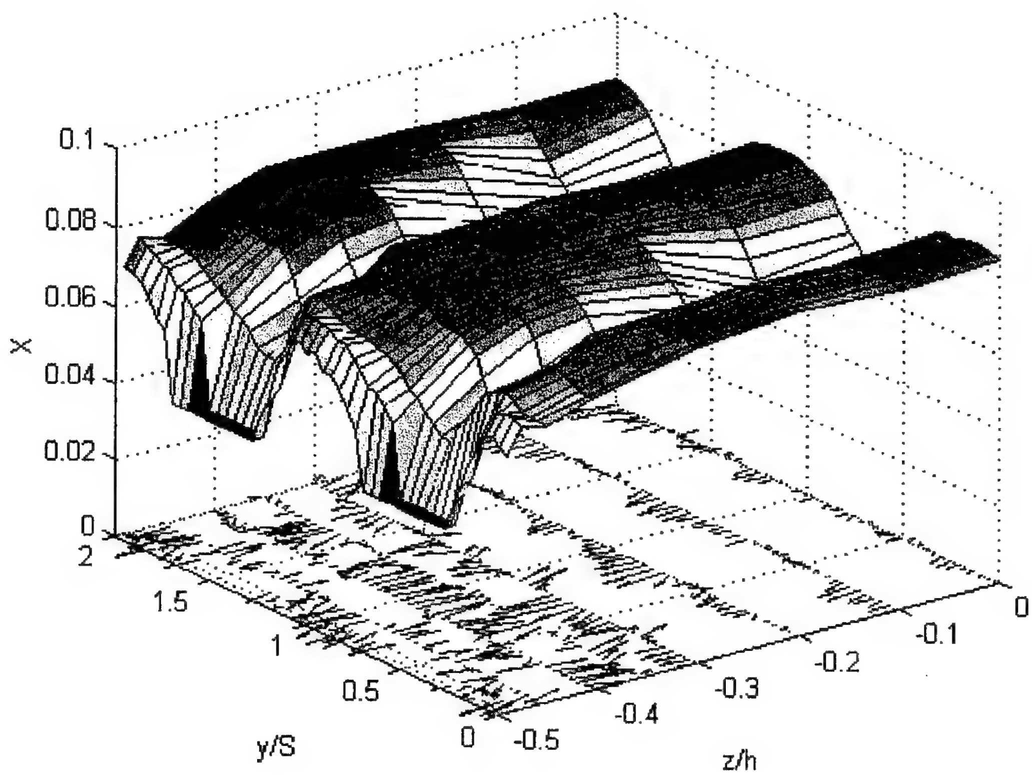

Figure 13. Summary Surface Plot of Non-Dimensional Velocity and Secondary Flow

Both surface plots, Fig.12 and Fig. 13, clearly show the total pressure and velocity deficit in the wakes, which become more complex as the endwall region is approached, i.e. double peaks appear at approximately 20% span (z/h = -0.3). The secondary flow vectors with respect to the probe orientation are, as expected, negligible at midspan. These increase significantly in the endwall region with some evidence of cross plane vortical flow; however, the scatter in the data and lack of resolution in the spanwise direction, i.e. only nine surveys across 0.5 span, restrict the resolution of the flow structures.

Loss coefficients were calculated using the equations in Appendix A for each spanwise survey. Figure 14 shows the spanwise mass-averaged loss coefficient from centerline to the endwall. The loss coefficient showed a minimum between 20-30% span, which was associated with the double peaks in the total pressure distribution, or narrowing of the wake width in that region (see five-hole probe plots, locations 4 and 5 in Appenidix C).

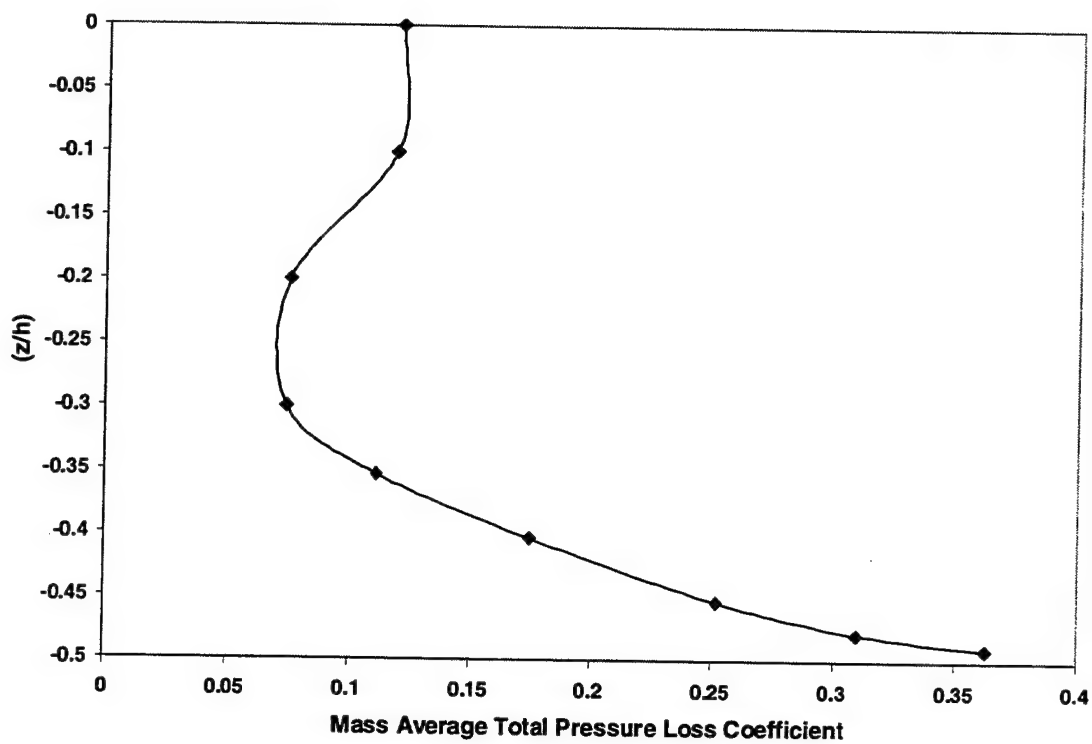

Figure 14. Spanwise Loss Distribution

B. LDV MEASUREMENTS

1. Inlet LDV Surveys

LDV measurements upstream of the test section were performed at Station 1 beginning at the centerline and moving toward the endwall region at locations 1, 2, 3, 4 and 5. Table 2 lists the coordinates associated with each spanwise survey location. Station 1 (Fig. 4) was located upstream of the test section at -30% axial chord ($-0.30C_{ac}$). Pitchwise surveys were performed over two complete blade passages (307.5 mm total).

One thousand data points were taken at each position of the survey for a total of 42 positions spaced 7.5 mm apart. Results at Station 1 in the form of velocity ratios referenced to the inlet velocity, V_{ref}, turbulence intensity referenced to V_{ref}, and the Reynolds stress correlation coefficient, c_{uv}, will be presented at each spanwise location.

a. Station 1 - Location 1

The velocity ratio is plotted in Fig.15. All three velocity ratios (total, axial, and tangential) showed a slight variation across the passage. This indicated that the potential influence of the blades was felt as far upstream as 30% axial chord, which resulted in the depressions in velocity spaced one blade passage width apart. The turbulence intensity is plotted in Fig. 16. Both the axial (Tu) and tangential (Tv) turbulence intensities were measured to have an average of 1.9%. This average value compared well with the previous study [Ref. 6]. It is interesting to note that the turbulence appears to be periodic at three perturbations per blade passage, or twice the inlet guide vane (IGV) spacing, suggesting that the wakes from the IGV's paired up prior to reaching Station 1. The Reynolds-stress correlation coefficient is plotted in Fig. 17. The average correlation value was approximately 0.1 which shows that the turbulent fluctuations were uncorrelated.

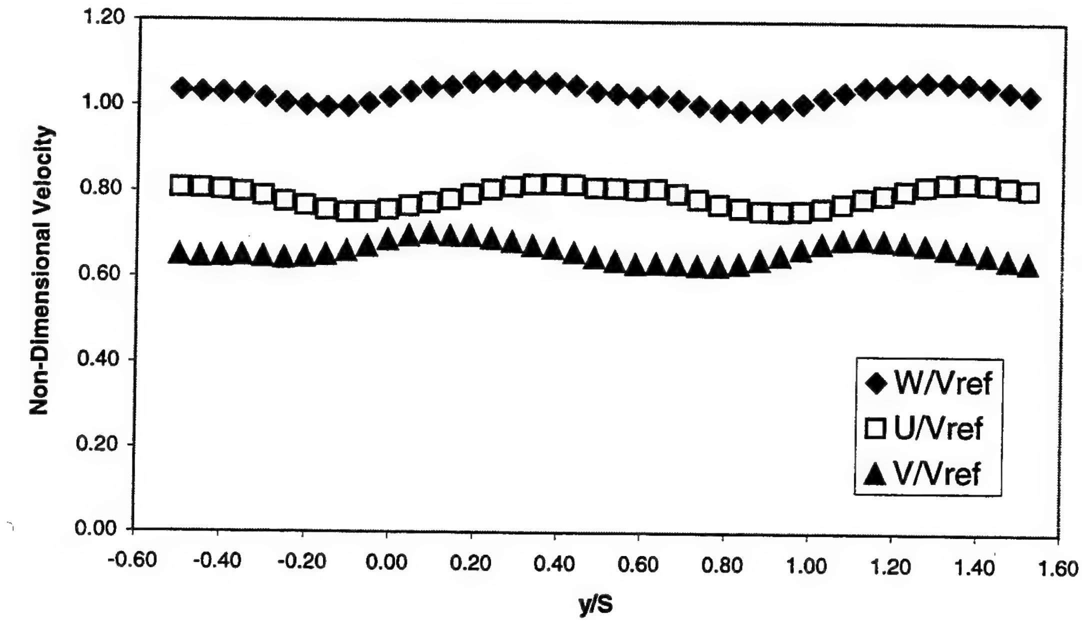

Figure 15. Inlet LDV Survey Location 1 - Velocity Ratios

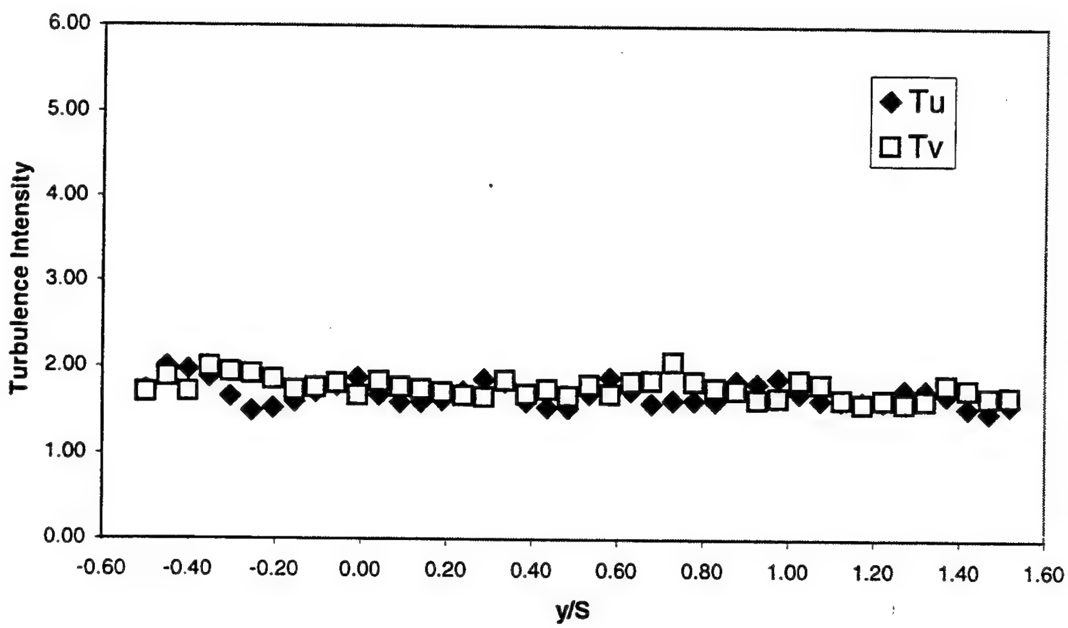

Figure 16. Inlet LDV Survey Location 1 - Turbulence Intensity

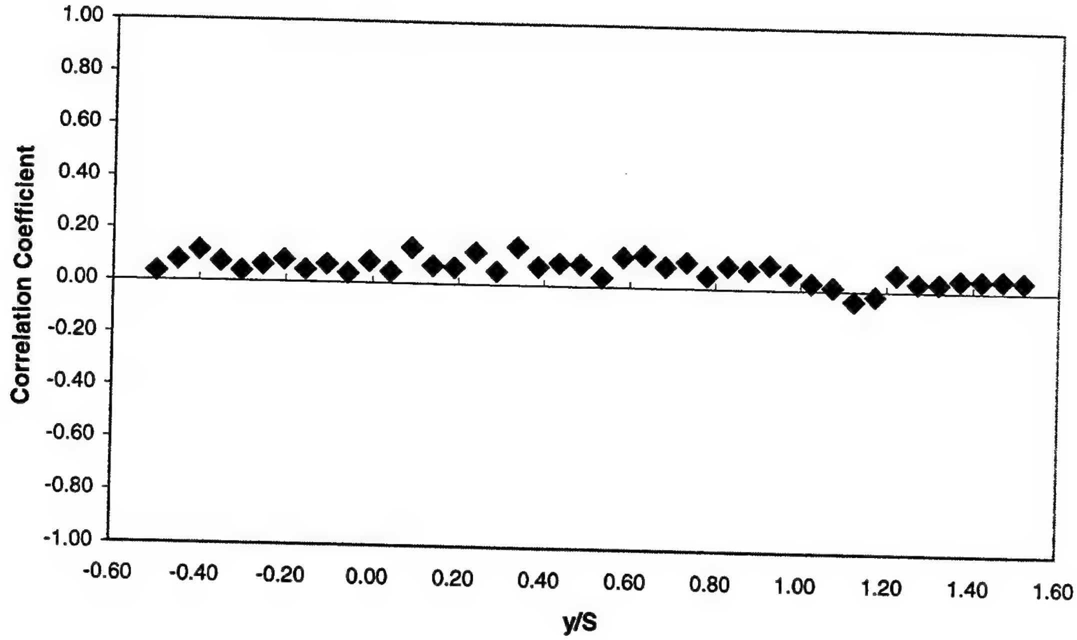

Figure 17. Inlet LDV Survey Location 1 - Reynolds Stress Correlation

b. Station 1 - Locations 2, 3, and 4

The surveys conducted at locations 2, 3, and 4 showed minimal or no changes in velocity ratios from the survey at location 1. Turbulence intensities remained constant until location 3 which only rose slightly to an average of 2.75% from 2%. The Reynolds stress correlation coefficient showed no change from the location 1 survey. Plots of velocity ratio, turbulence intensity and Reynolds stress correlation can be viewed in Appendix E. Location 5 was not tested.

c. Station 1 - Location 6

Figure 18 is a plot of the velocity ratios. All velocity ratios decreased from the values seen at location 1. The probe volume was within the tunnel endwall boundary layer and the overall flow was reduced.

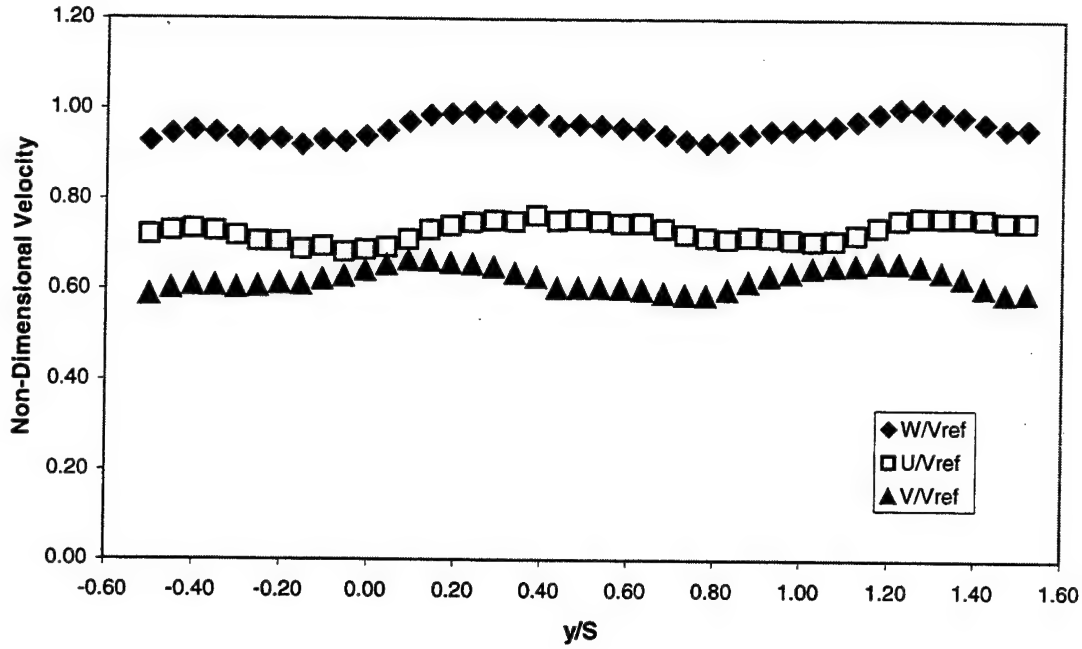

Figure 18. Inlet LDV Survey Location 6 - Velocity Ratios

Figure 19 shows the turbulence intensities at this location. There was a uniform increase in both axial and tangential turbulence intensities. The average was 4% which was double the 2% found at location 1. Figure 20 shows the Reynolds stress correlation, which remained unchanged in the spanwise direction (average of 0.1, or no correlation).

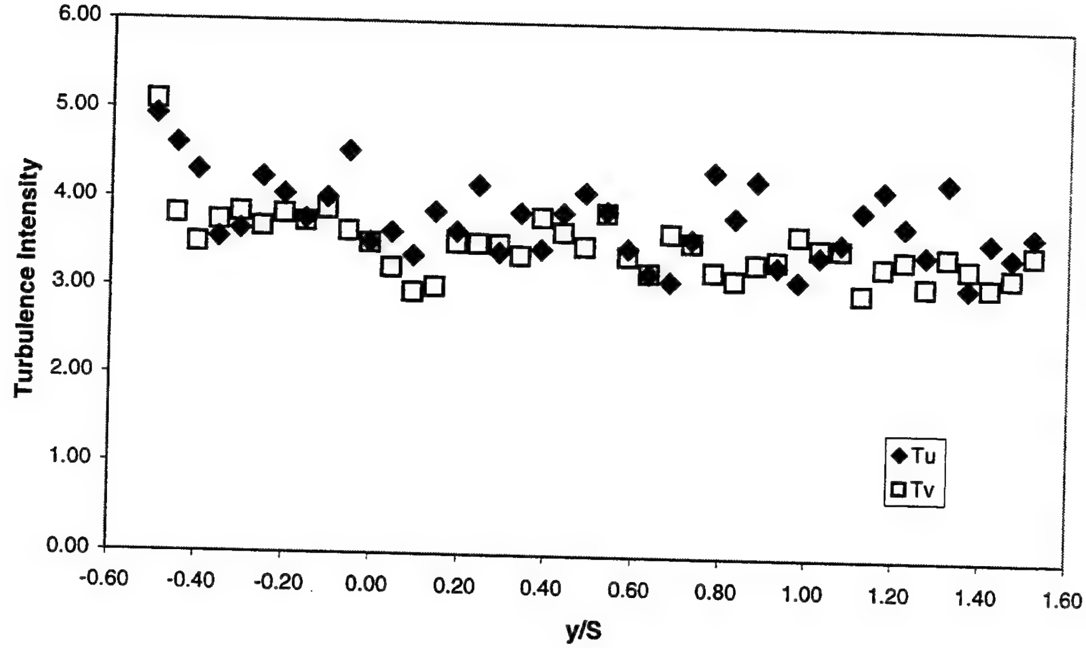

Figure 19. Inlet LDV Survey Location 6 - Turbulence Intensity

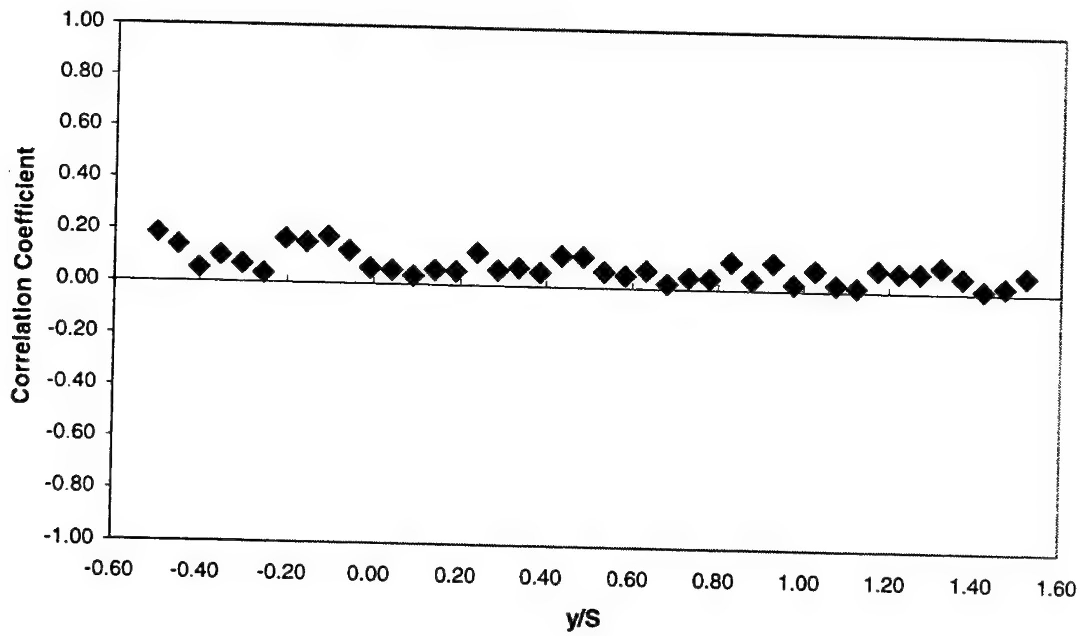

Figure 20. Inlet LDV Survey Location 6 - Reynolds Stress Correlation

2. Wake LDV Surveys

LDV measurements downstream of the test section were performed at Station 13 (Fig. 7) beginning at the centerline and moving toward the endwall region at spanwise locations 1, 2, 3, and 4 (Table 2). Station 13 was located downstream of the test section at 120% axial chord ($1.20C_{ac}$). Pitchwise surveys were performed over two blade passages (255 mm total). One thousand data points were taken at each position of the survey for a total of 35 positions spaced 7.5 mm apart. Results at Station 13 in the form of velocity ratios referenced to the inlet reference velocity, V_{ref}, turbulence intensity referenced to V_{ref}, and the Reynolds stress correlation coefficient, C_{uv}, will be discussed to characterize the wake flow in the test section.

a. Station 13 - Location 1

Figure 21 is a plot of the velocity ratios, which were uniform in the free stream, with depressions in the vicinity of the blade trailing edge position. Figure 22 is a plot of the turbulence intensity, which was relatively constant in the freestream (2%), with double peaks in both the axial and tangential turbulence at the trailing edge of the blades. The maximum axial turbulence intensity was 22%, and the maximum tangential turbulence intensity was 10%.

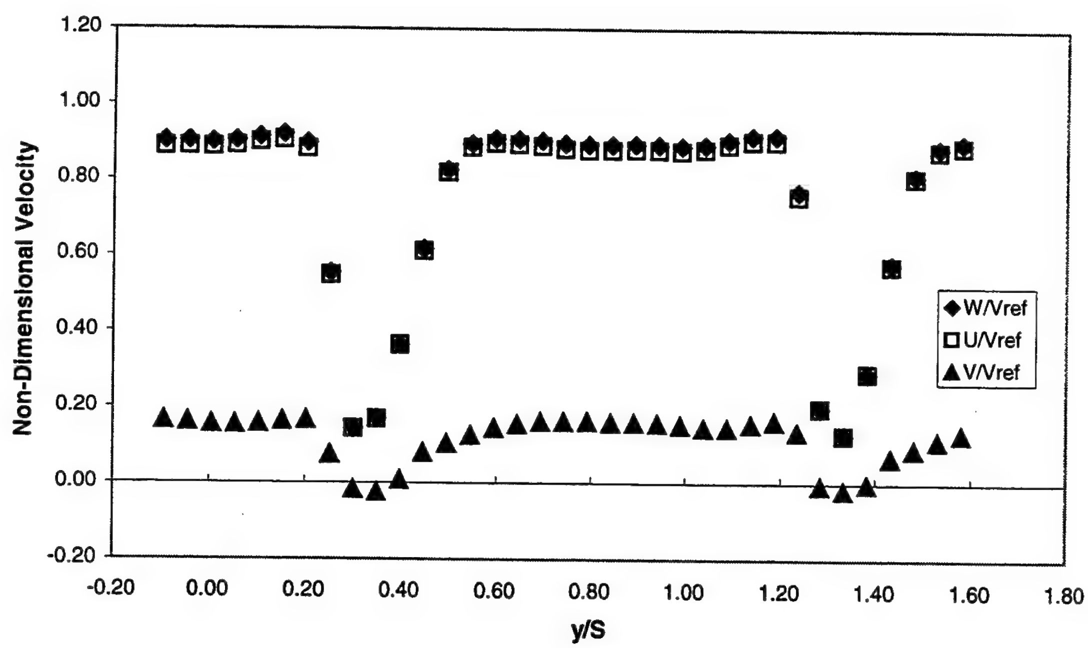

Figure 21. Wake LDV Survey Location 1 - Velocity Ratios

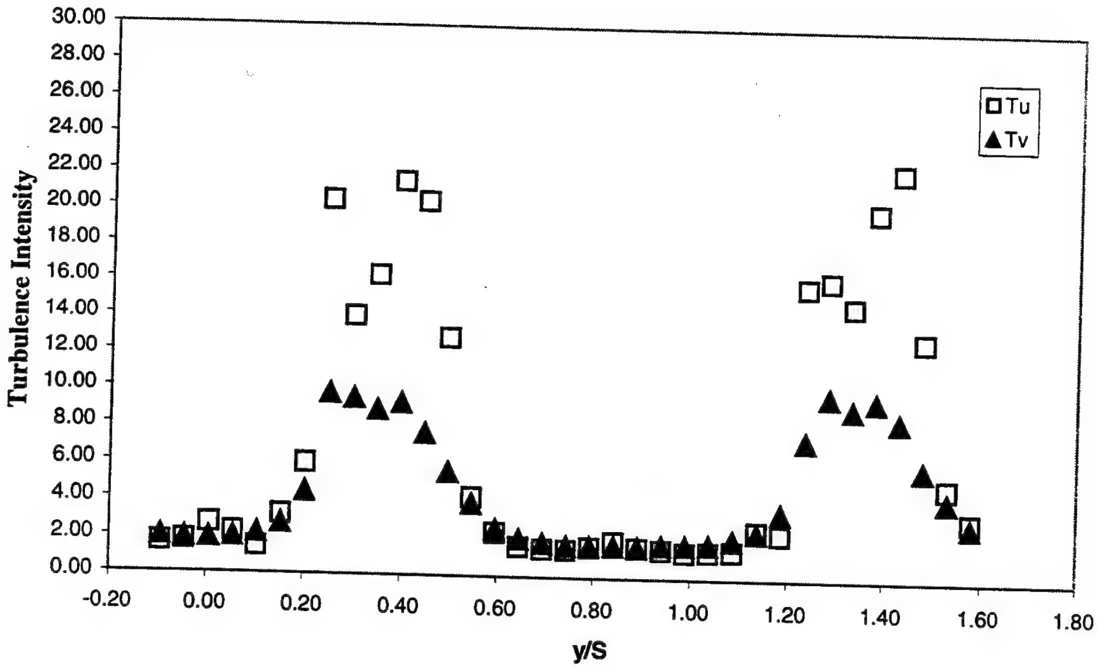

Figure 22. Wake LDV Survey Location 1 - Turbulence Intensity

Figure 23 is a plot of the Reynolds stress correlation, which varied from -0.10 to 0.20, implying that little or no correlation was evident.

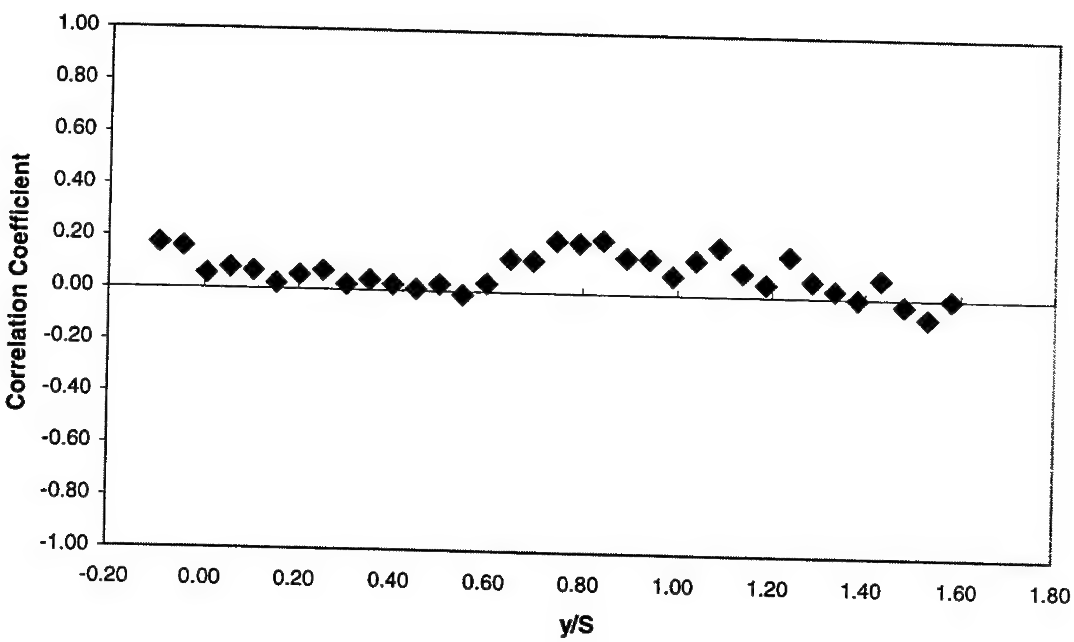

Figure 23. Wake LDV Survey Location 1 - Reynolds Stress Correlation

b. Station 13 - Location 2

Figure 24 is a plot of the velocity ratios at location 2. The velocity deficit increased from location 1. Figure 25 shows that the average turbulence intensity in the freestream remained constant at 2%, and that the double peaks in both the axial and tangential turbulence seen in Fig. 22 were still present at location 2. The maximum axial turbulence intensity was 22%, and the maximum tangential turbulence intensity was 10%. Figure 26 is a plot of the Reynolds stress correlation, which varied from -0.01 to 0.30, implying that little or no correlation was evident.

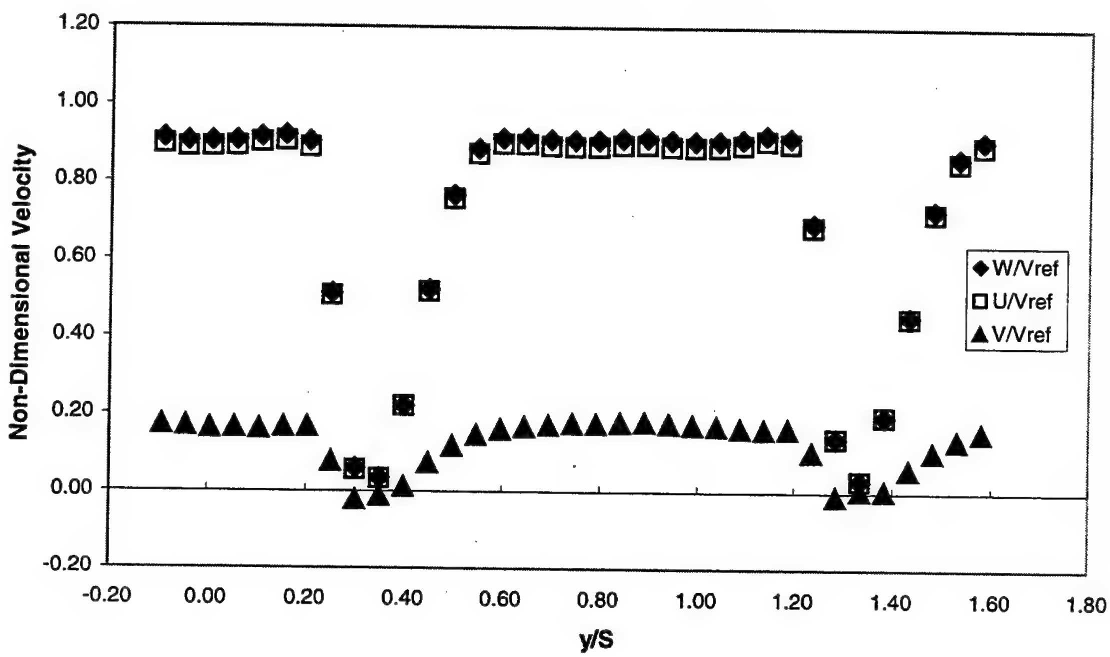

Figure 24. Wake LDV Survey Location 2 - Velocity Ratios

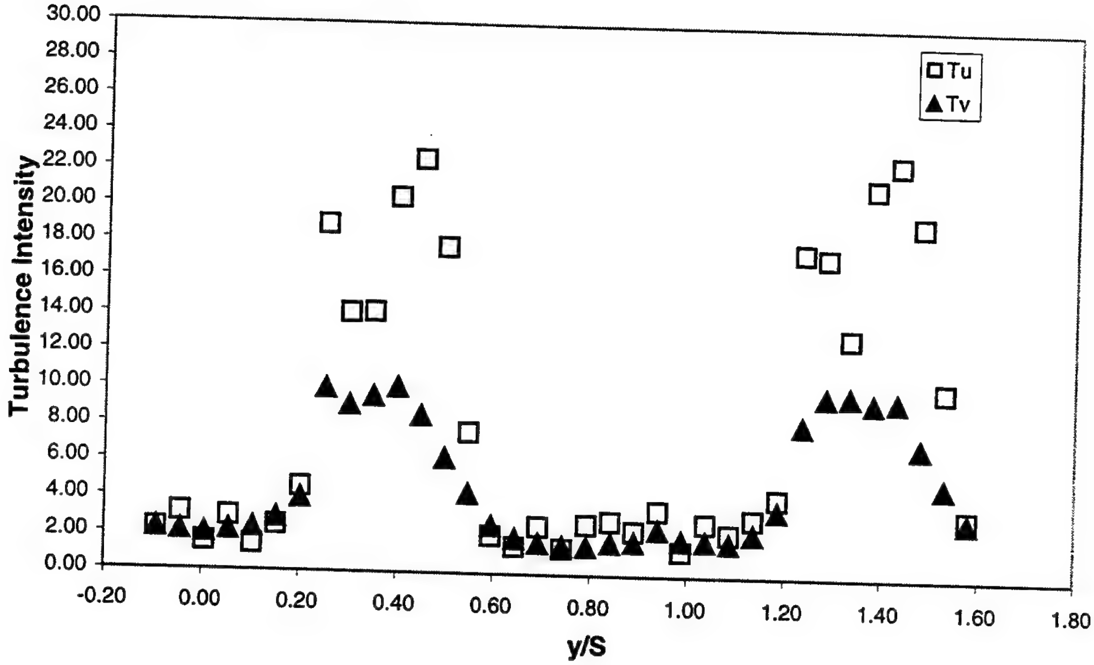

Figure 25. Wake LDV Survey Location 2 - Turbulence Intensity

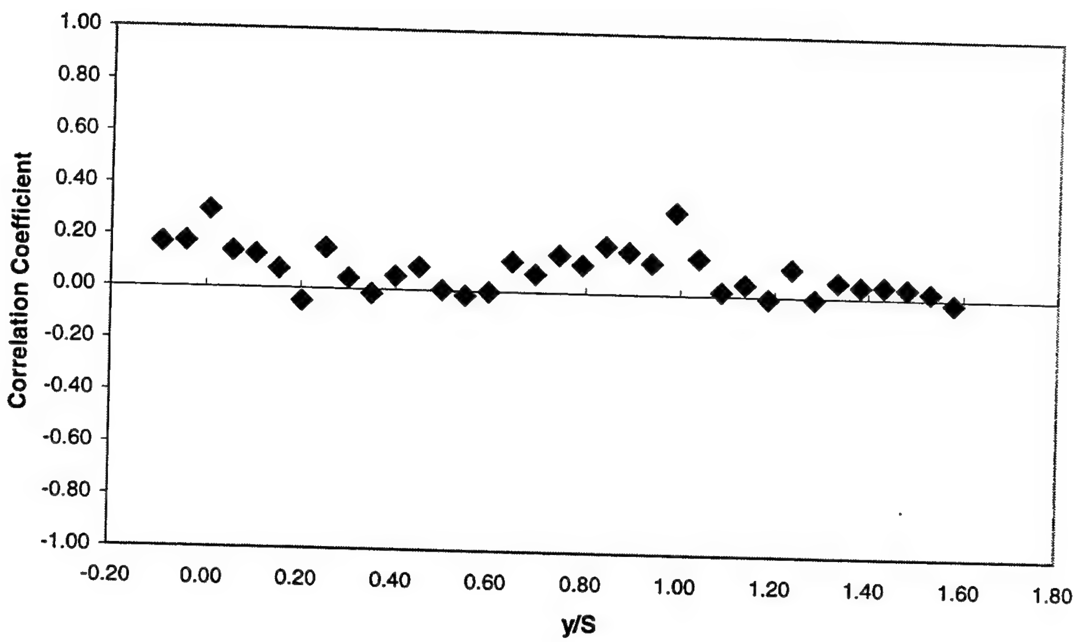

Figure 26. Wake LDV Survey Location 2 - Reynolds Stress Correlation

c. *Station 13 - Location 3*

Figure 27 is a plot of the velocity ratios, which were uniform in the free stream, with smaller depressions in the vicinity of the blade trailing edge position as compared to both locations 1 and 2. Figure 28 is a plot of the turbulence intensity, with only single peaks evident in both the axial and tangential turbulence at the trailing edge of the blades. Overall, both axial and tangential turbulence intensities increased in the wake, but remained unchanged in the freestream from location 2. Figure 29 is a plot of the Reynolds stress correlation, which varied from -0.20 to 0.20, implying that little or no correlation was evident.

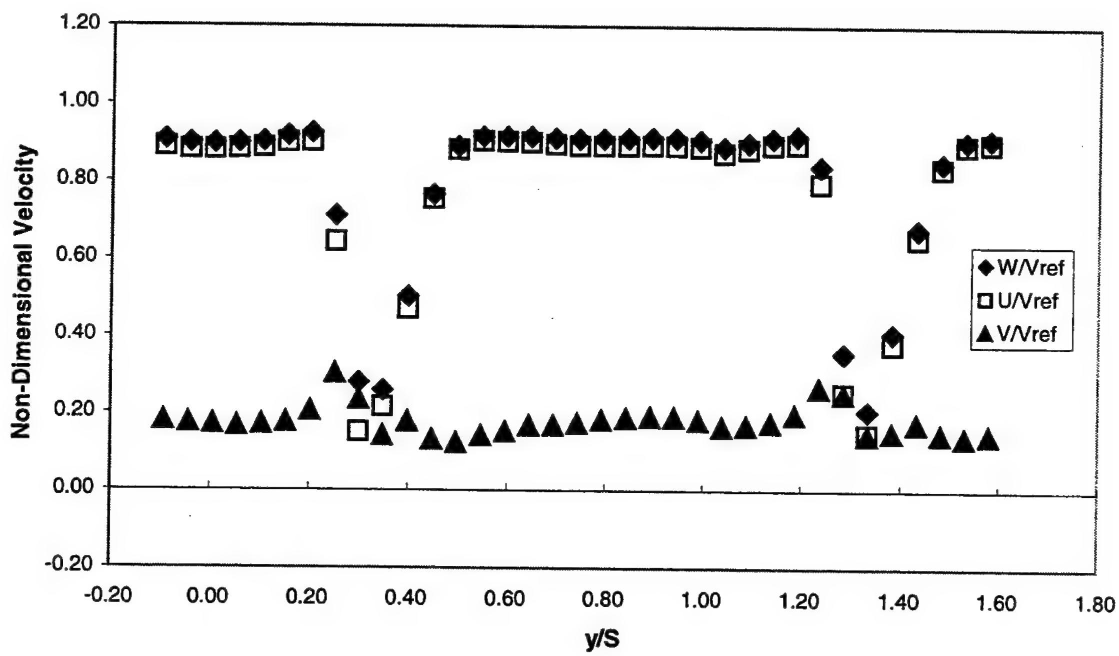

Figure 27. Wake LDV Survey Location 3 - Velocity Ratios

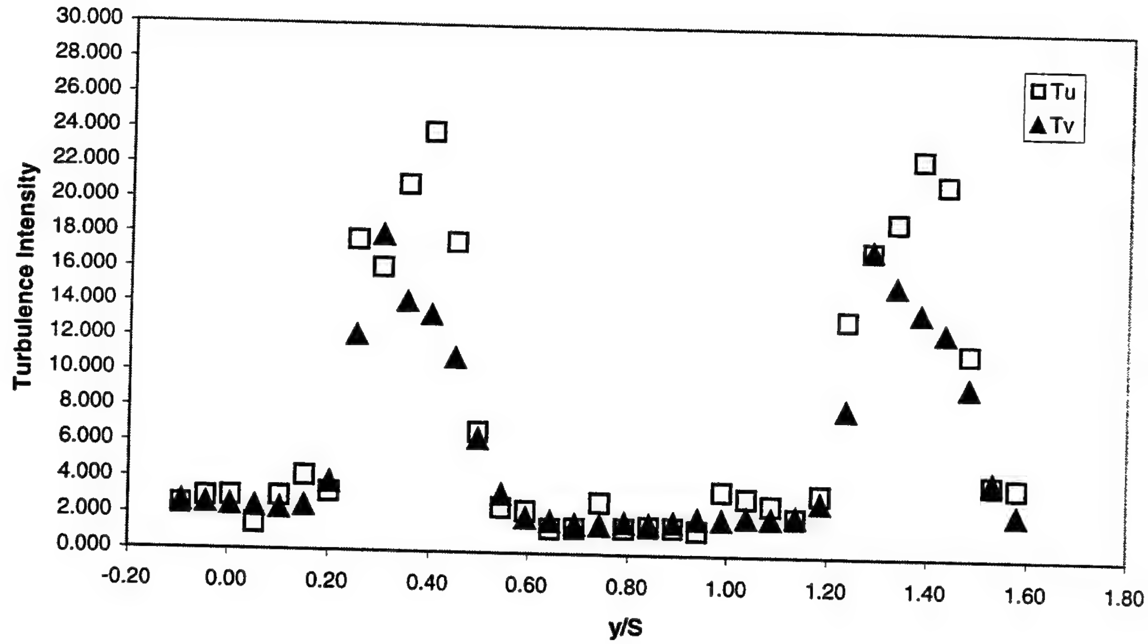

Figure 28. Wake LDV Survey Location 3 - Turbulence Intensity

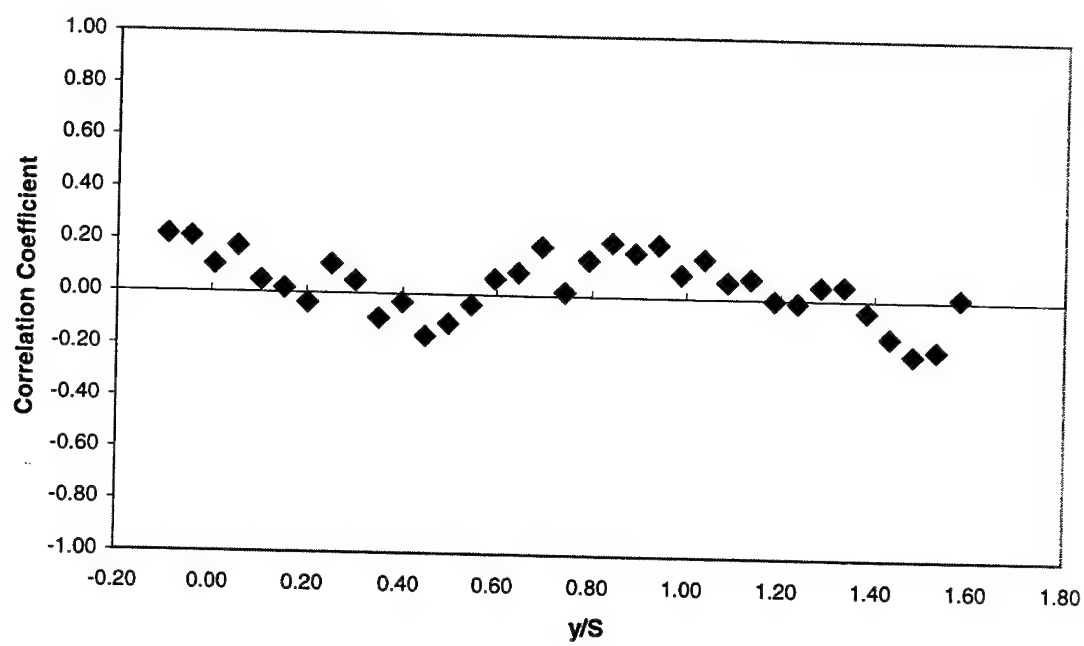

Figure 29. Wake LDV Survey Location 3 - Reynolds Stress Correlation

d. ***Station 13 - Location 4***

Figure 30 is a plot of the velocity ratios. The axial velocity deficit narrowed substantially as compared to locations 1, 2, and 3. Figure 31 is a plot of the turbulence intensity. The freestream turbulence intensity increased to an average of 3%, which was the largest freestream value of all locations. The maximum axial turbulence was 20%. The maximum tangential turbulence was 18%. Figure 32 is a plot of the Reynolds stress correlation, which varied from -0.15 to 0.30, implying that little or no correlation was evident.

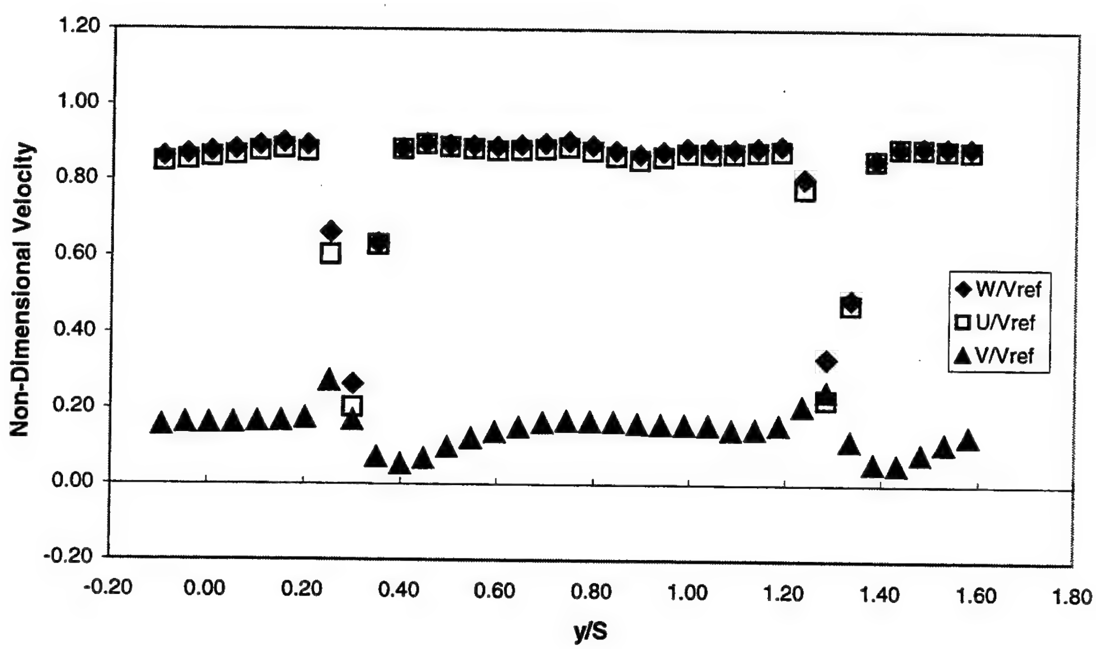

Figure 30. Wake LDV Survey Location 4 - Velocity Ratios

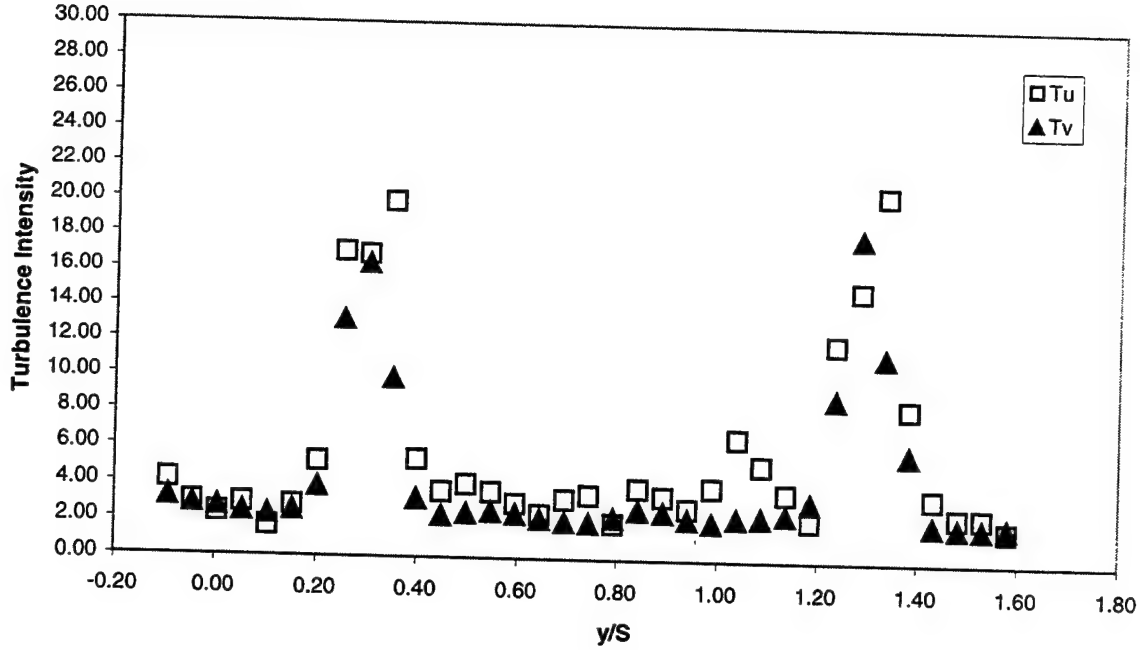

Figure 31. Wake LDV Survey Location 4 - Turbulence Intensity

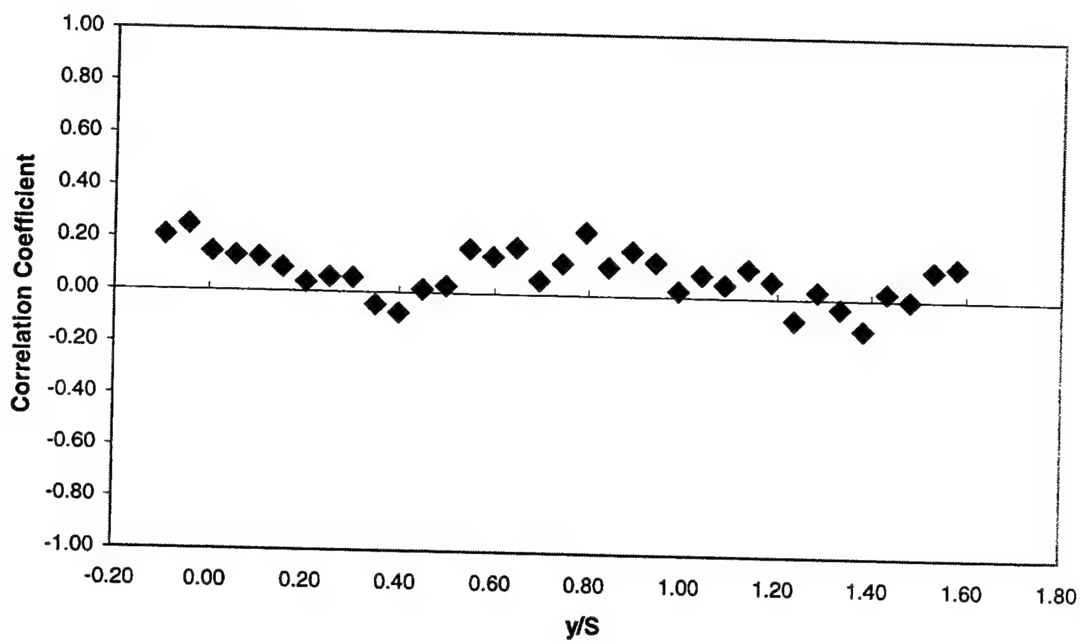

Figure 32. Wake LDV Survey Location 4 - Reynolds Stress Correlation

V. COMPUTATIONAL FLUID DYNAMIC (CFD) ANALYSIS

A. PURPOSE

The purpose of this numerical analysis was to expand the work completed by Schnorenberg [Ref. 4] and Grove [Ref. 5] in an attempt to model the flow phenomena measured experimentally at off-design incidence angles of 38 and 39.5 degrees. Computed blade surface pressure coefficient distributions were compared with those obtained from experimental results. SWIFT [Ref. 11], which was a follow-on to Rotor Viscous Code 3-D (RVC3D - used by Schnorenberg and Grove), was used as the flow solver. By comparing the CFD solution with experimental data, confidence was gained in the use of the code, which could be used to produce designs that give improved blade performance.

B. GRID GENERATION

A two dimensional C-type grid was computed using a modified version of the code GRAPE (Grid About Airfoils using Poisson's Equations). The grid size was 340 x 49 and the grid coordinates were generated based on manufacturing dimensions. A three-dimensional grid was built using a program called STACK, which took the two-dimensional C-type grid and extended it outward in the spanwise direction (z) by 92 points. One entire blade span, as was present in the LSCWT, was modeled in order to remove the effects of a symmetry-plane boundary (vice half a blade span with symmetry plane [Refs. 4 and 5]). The final grid had dimensions 340 x 49 x 92, and is shown in surface grid form in Fig. 33.

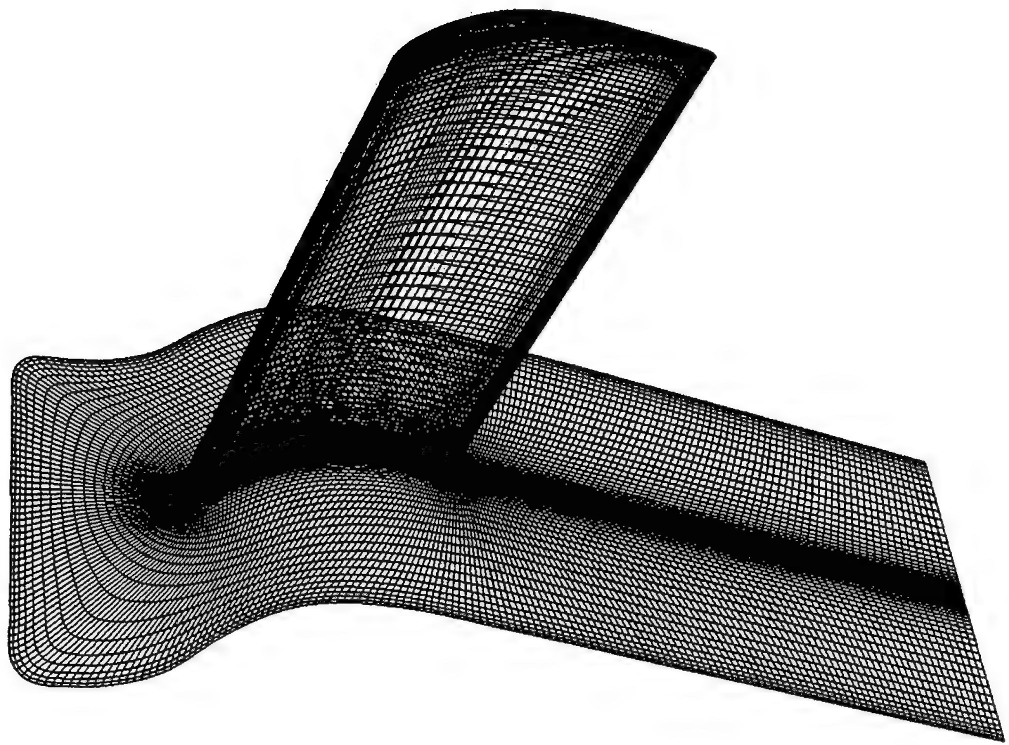

Figure 33. CD Blade Modeled with C-Type Grid

C. COMPUTATIONAL SOLVER

CFD analysis was performed using SWIFT version 107. SWIFT is a three-dimensional, thin-layer Navier-Stokes code for turbomachinery, which has a finite-difference formulation using an explicit multi-stage Runge-Kutta scheme with variable time-step and implicit residual smoothing. Turbulence effects were modeled using Wilcox's k-omega model (low Reynold's number form).

The required inputs for running SWIFT included the three-dimensional grid and a namelist file of input parameters which allowed for specification of boundary conditions and flow parameters. A constant Courant number (CFL) of 5.0 was used throughout all the calculations. An initial boundary layer thickness of 0.6 of half-span was used to model the inlet boundary layer on the endwall. Inlet flow angle was varied by changing the parameter "Prat" (hub exit static pressure to inlet reference total pressure ratio, P_{hub_exit}/P_o). Appendix F contains a sample input namelist, showing the initial parameters that were used to run the code. Table 3 lists the "Prat" input combinations investigated.

Table 3. CFD Parameter Inputs

Test Case #	Prat ($P_{hub\ exit}/P_o$)	Boundary Layer Thickness (fraction of half-span)	Inlet Flow Angle
1	0.9718	0.6	35.0°
2	0.975	0.6	37.15°
3	0.9765	0.6	38.14°
4	0.977	0.6	38.6°
5	0.978	0.6	39.35°
6	0.978	0.4	38.8°
7	0.978	0.8	39.8°

Computed blade surface pressure distributions were then compared to the actual C_p distributions recorded by Schnorenberg [Ref. 4] and Grove [Ref. 5]. Neither blade pressure profile was matched exactly, so the boundary layer thickness was modified to investigate the effects on the code solution with "Prat" set to 0.978.

D. RESULTS AND DISCUSSION

The seven test cases investigated in the present study are shown in Table 3. Test case #3 resulted in a converged solution (3 orders of magnitude) with an inlet flow angle of 38.14°, which most closely matched the inlet flow angle of 38.0° recorded by Schnorenberg [Ref. 4]. Test case #5 resulted in a converged solution, with an inlet flow angle of 39.35°, which most closely matched the inlet flow angle of 39.5° recorded by Grove [Ref. 5]. Comparisons of experimental blade surface pressure coefficients with CFD results were made. It was found that pressure-side predictions matched closely with experimental data for all cases, whereas suction-side predictions did not match up well with experimental data. Pressure profiles seemed to agree qualitatively in the axial direction, but the suction pressure magnitudes were much lower. Using "Prat = 0.978", the boundary layer thickness was varied from 0.4 of half-span to 0.8 of half-span in an attempt to more closely match the profile determined experimentally by Nicholls [Ref. 6]. The overall Cp profile did not change, but rather the inlet flow angle increased/decreased with the corresponding increase/decrease in the boundary layer thickness.

1. Coefficient of Pressure Distributions and Residual Histories

Figure 34 is a plot of the Cp profile calculated for Test Case #3. The CFD results were plotted against the experimental Cp profile recorded by Schnorenberg [Ref. 4]. Good correlation is seeen on the pressure side of the blade but not the suction side of the blade. Figure 35 is a plot of the solution's residual history. The solution was run for 20000 iterations, resulting in 3rd order convergence.

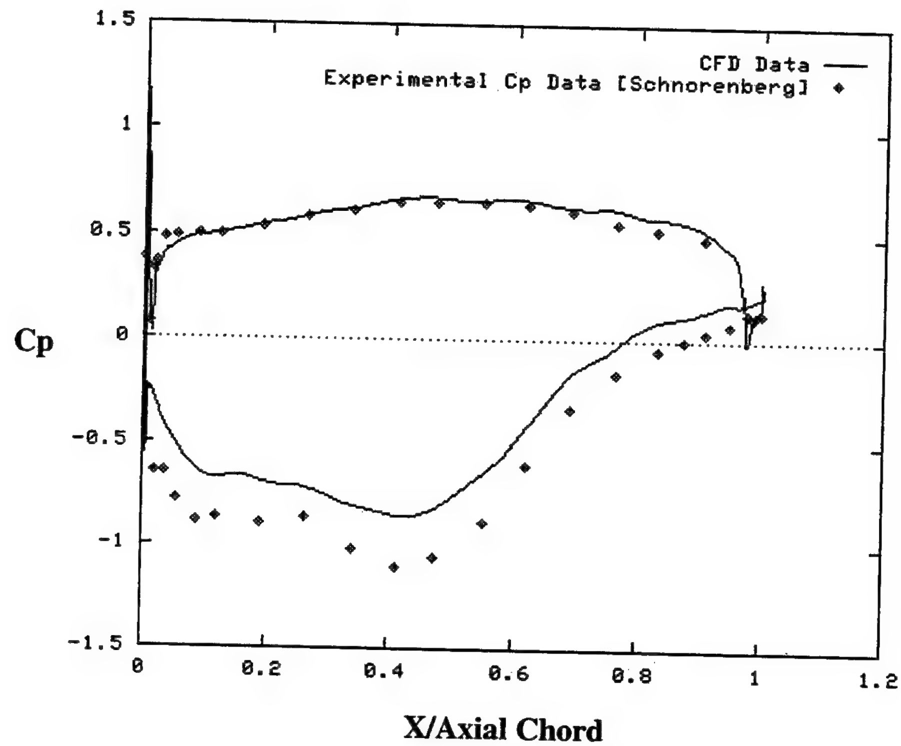

Figure 34. Blade Surface Pressure Coefficient Distribution - Test Case #3

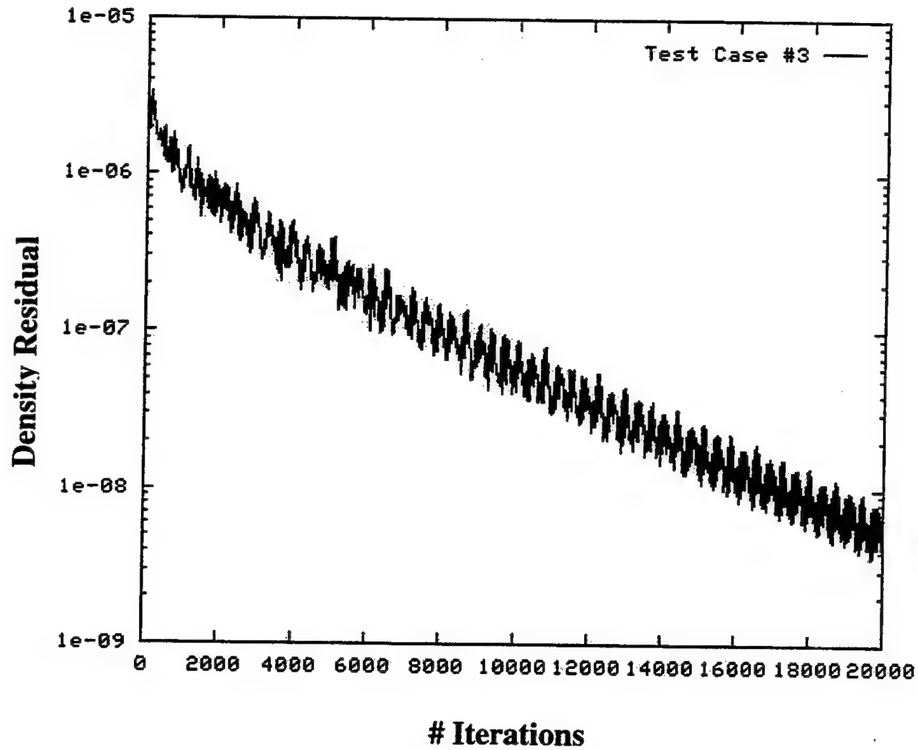

Figure 35. Convergence History - Test Case #3

Figure 36 is a plot of the Cp profile calculated for Test Case #5. The CFD results were plotted against the experimental Cp profile recorded by Grove [Ref. 5]. Once again, good correlation is seen on the pressure side of the blade but not the suction side of the blade. Figure 37 is a plot of the solution's residual history. The solution was run for 30000 iterations, resulting in 3rd order convergence.

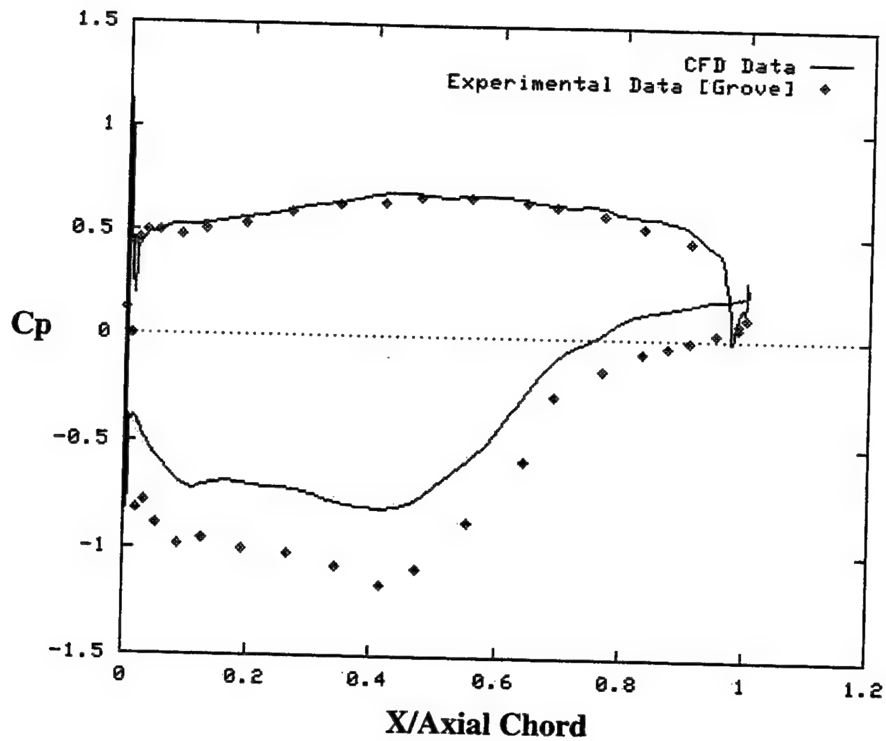

Figure 36. Blade Surface Pressure Coefficient Distribution - Test Case #5

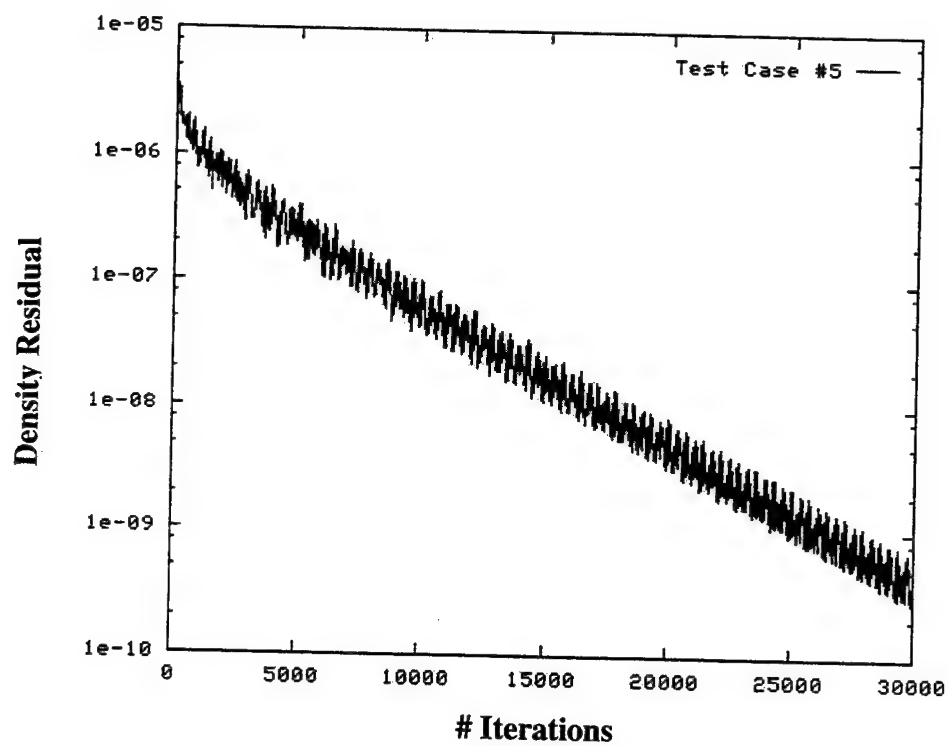

Figure 37. Residual History - Test Case #5

Figure 38 is a plot of the Cp profile calculated for Test Case #6 (boundary layer thickness reduced to 0.4 of half-span). Figure 39 is a plot of the Cp profile calculated for Test Case #7 (boundary layer thickness increased to 0.8 of half-span). Both CFD results were plotted against the experimental Cp profile recorded by Grove [Ref. 5]. There were no discernible changes in the Cp profiles between cases 5, 6, and 7. The boundary layer thickness did not effect the Cp distribution, but did affect the final inlet flow angle, which increased with increased boundary layer thickness and decreased with decreased boundary layer thickness. Residual history plots and convergence were similar to the test cases previously discussed.

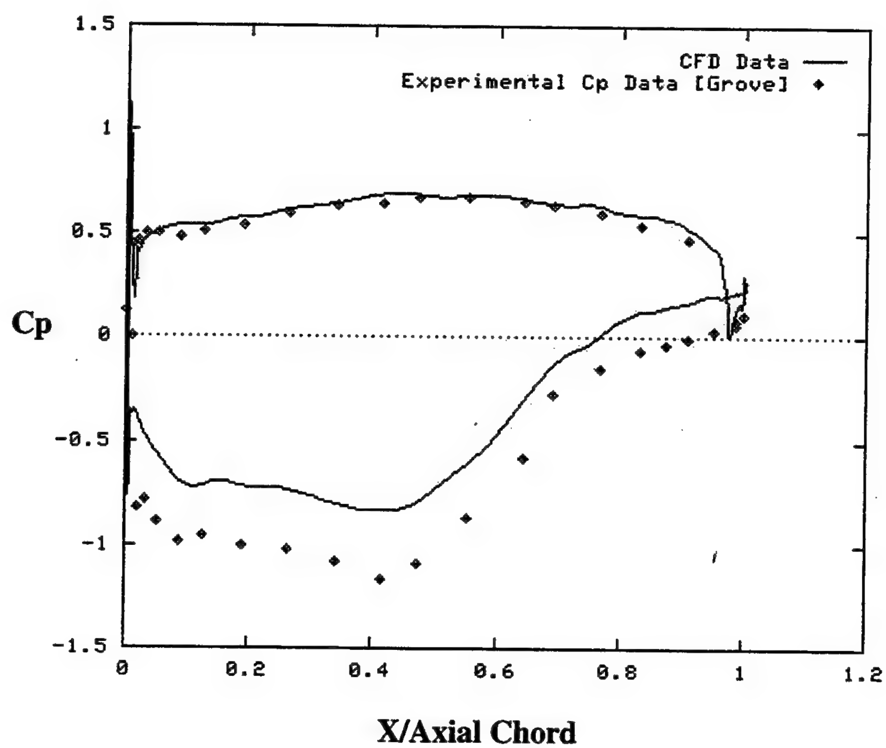

Figure 38. Blade Surface Pressure Coefficient Distribution - Test Case #6

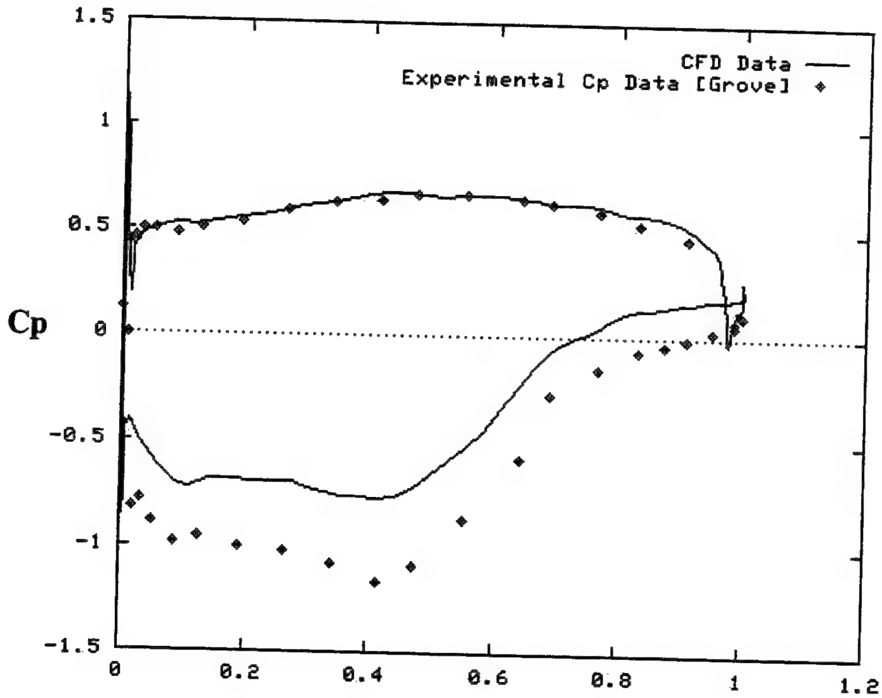

Figure 39. Blade Surface Pressure Coefficient Distribution - Test Case #7

2. Comparison with Five-Hole Probe Data

Downstream total pressure-to-inlet freestream total pressure (Pt_2/Pt_{1INF}) values were recorded at each location during the five-hole pressure probe survey. Figure 40 shows the surface plot of Pt_2/Pt_{1INF} and Fig. 41 is a contour plot of the same distribution. The plots are not smooth due to the minimal number of data points collected from the nine irregularly spaced spanwise surveys. The freestream is centered about $y/S = 1$ and the two wakes are centered about $y/S = 0.5$ and 1.5. Along each wake are two areas of minimum pressure at $z/h = 0$ and $z/h = -0.5$ which correspond to the separated regions in the near wake. Figure 42 is a contour plot of the CFD prediction, where the free stream is centered about $y/S = 0.5$ and 1.5, and the wakes are centered about $y/S = 0$, 1.0 and 2.0. Only one area of minimum pressure is seen in the wake regions at $z/h = -0.43$. This suggests that the flow in the CFD solution was not separated on the centerline, and the contour plots were not similar. Figure 43 is the corresponding CFD surface plot of Pt_2/Pt_{1INF}. When compared to Fig. 40, it is evident these plots are also not similar. Flow separation, which occured experimentally on the centerline, did not occur in the CFD

solution. However, the overall levels of total pressure ratio were similar in the experiment and in the CFD solution.

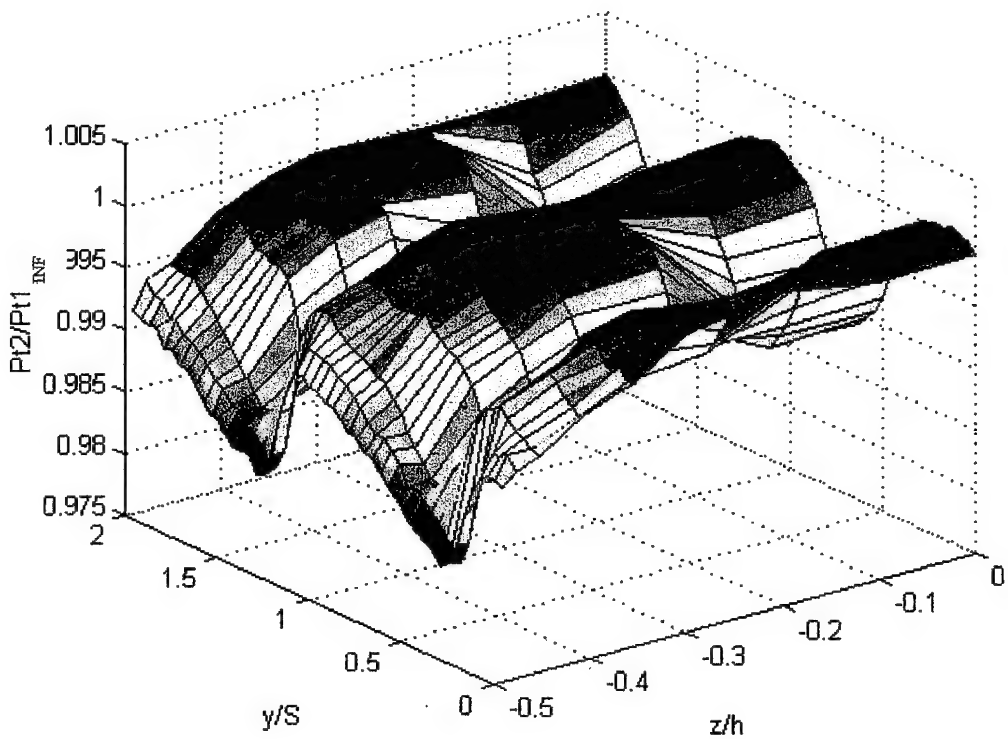

Figure 40. Surface Plot of Pt_2/Pt_{1INF} - Five-Hole Probe

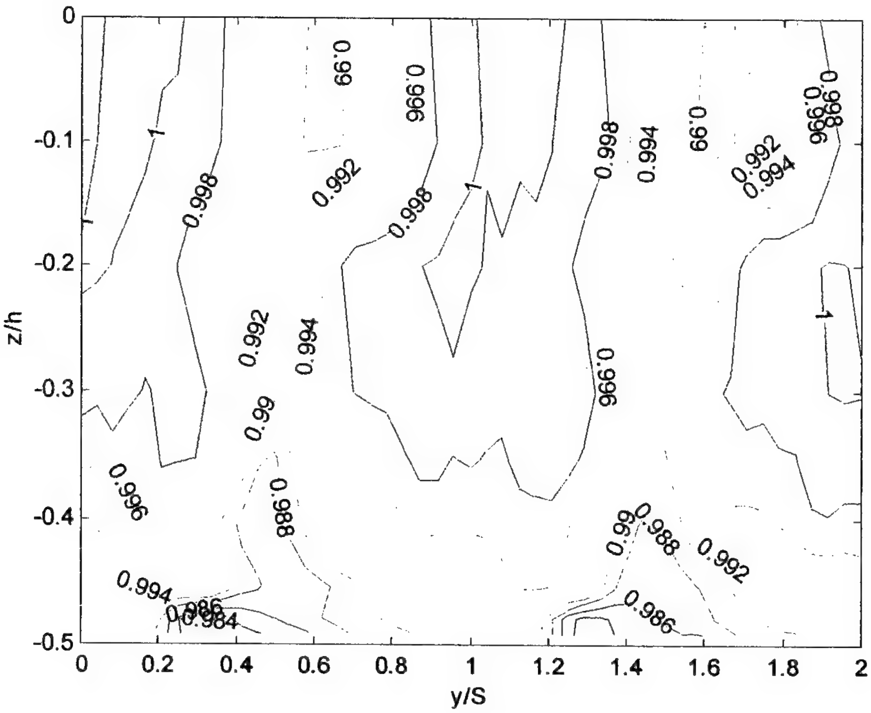

Figure 41. Contour Plot of Pt_2/Pt_{1INF} - Five-Hole Probe

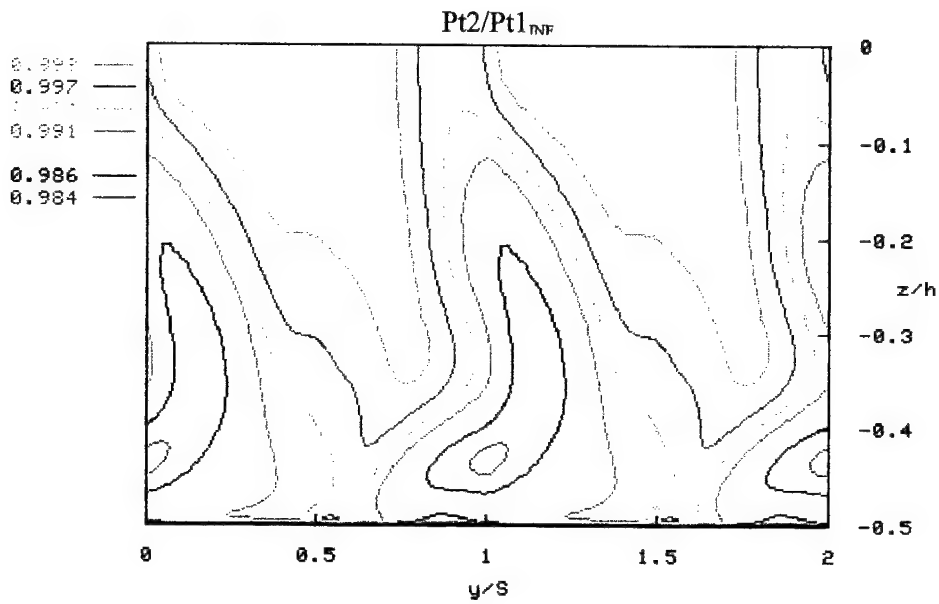

Figure 42. Contour Plot of Pt_2/Pt_{1INF} - CFD Prediction (Test Case #5)

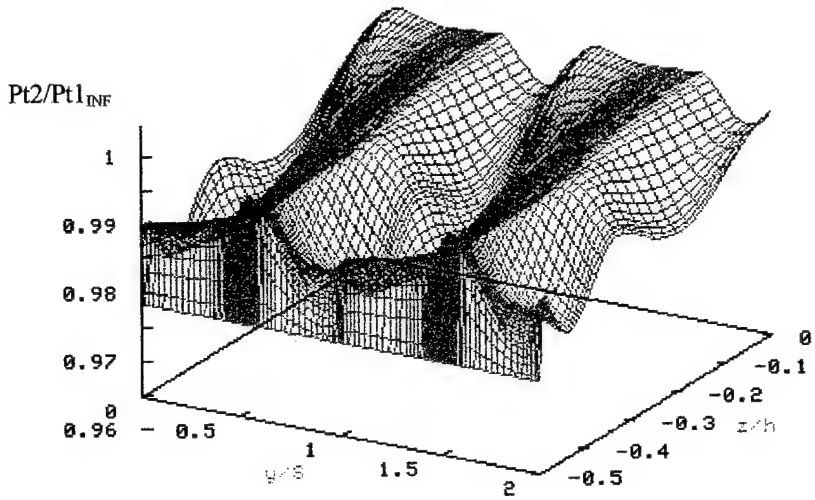

Figure 43. Surface Plot of $Pt_2/Pt_{1_{INF}}$ - CFD Prediction (Test Case #5)

3. FAST Flow Analysis

Figure 44 shows the experimental surface flow visualization conducted by Nicholls [Ref. 6]. FAST analysis of Test Case #5 provided CFD flow visualization results which are seen in Fig. 45. The color lines are particle traces initiated at different locations on the suction surface of the blade. The flow turned inward towards midspan in a helical pattern. This flow feature can also be seen in Fig. 44. The yellow particle traces indicated that flow reversal was predicted in the corner region, however, the two corner stall cells did not merge into one, as was seen in the experiment (Fig. 44).

Figure 44. Flow Visualization at Re = 640,000 [From Ref. 6]

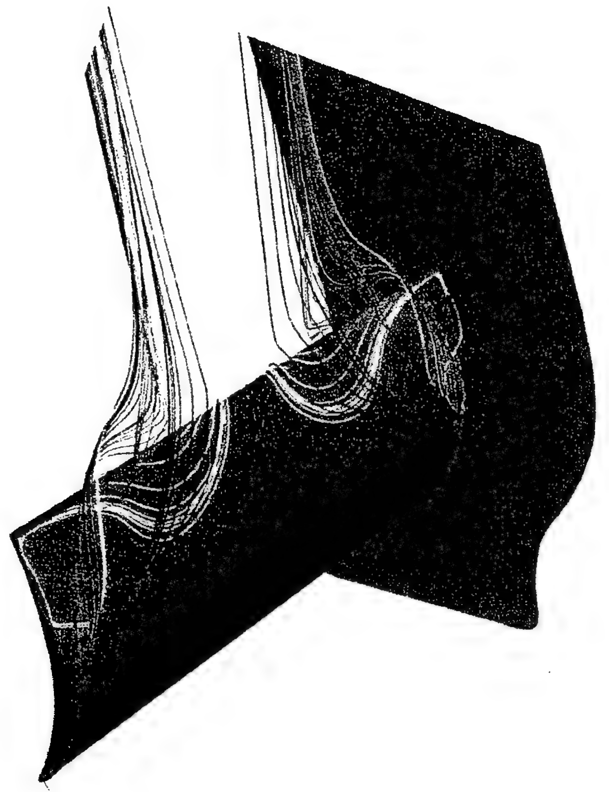

Figure 45. Particle Traces over the Full Blade Span

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Second-generation controlled-diffusion compressor blade sections, which modeled the midspan section of NASA's stator 67B, were investigated in the LSCWT. The objective of the study was the characterization of the flow in the endwall region.

Five-hole pressure probe surveys were completed at various spanwise locations in the wake of the blades. These measurements illustrated the complex nature of the flow in the wake through the determined stagnation pressure distribution, total velocity distribution, and secondary flow vector plot. Mass-average total-pressure loss coefficients were calculated at each five-hole probe survey location, giving the overall spanwise loss distribution. Two-component LDV surveys were completed at the inlet and in the wake over a range of spanwise locations which more extensively characterized the flow.

Full spanwise CFD analysis was performed, vice previous half span analyses, and results were in reasonable agreement with experimental data. Vortex flow at the trailing edge of the blade and near the endwall was indicated by the solution. Some areas of reverse flow were found but not at midspan.

B. RECOMMENDATIONS

Further five-hole probe and LDV studies should be performed at closer spanwise locations, in order to fully characterize the flow in the wake. This will provide a more detailed mapping of the secondary airflow. Inlet five-hole probe surveys also need to be performed to characterize the nature of the incoming endwall boundary layer, particularly the pitchwise unevenness due to wakes from the inlet guide vanes. Three-dimensional LDV surveys should be performed in order to characterize the flow in the endwall region. Lastly, further CFD studies should be conducted to attempt to completely match the coefficient of pressure distributions found experimentally, by modeling the tunnel boundary layer distribution and varying the available code input parameters.

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APPENDIX A: FIVE-HOLE PROBE EQUATIONS

The five-hole probe data were reduced using the following equations:

Non-dimensional Velocity: $X = \frac{V}{V_t}$ where $V_t = \sqrt{2C_pT_t}$ where T_t is the stagnation temperature and C_p is specific heat at constant pressure.

Mach No. sensitivity: $\beta = \frac{p_1 - p_{avg}}{p_1}$ where $p_{avg} = \frac{p_2 + p_3 + p_4 + p_5}{4}$ and subscripts 1-5 denote the ports on the probe.

Pitch Sensitivity: $\gamma = \frac{p_4 - p_5}{p_1 - p_{avg}}$ Yaw Sensitivity: $\delta = \frac{p_2 - p_3}{p_1 - p_{avg}}$

AVR: $$\frac{\int_0^s c_{z2}dx}{\int_0^s c_{z1}dx}$$

where c_{z1} and c_{z2} are the components of velocity normal to the leading edge plane of the cascade at the lower and upper traverse locations respectively.

Loss Coefficient: $\omega = \frac{\overline{C_{pt1}} - \overline{C_{pt2}}}{\overline{C_{pt1}} - \overline{C_{ps1}}}$ where $\overline{C_{pt1}} = \frac{P_t}{P_{plenum}}$, $\overline{C_{ps1}} = \frac{P_s}{P_{plenum}}$ and

$$\overline{C_{pt2}} = \frac{1}{AVRc_{z1}S}\int_0^s \frac{P_{t2}}{P_{plenum}} c_{z2}dx$$

Here, subscripts 1 and 2 denote upstream and downstream of the cascade test section. Furthermore, 't' denotes Prandtl probe total pressure, 's' denotes Prandtl probe static pressure, and $P_{t2} = P_1$ on the five-hole probe.

The Matlab code "fhpsurveys.m" used non null-yaw probe calibration coefficients computed by "calibration.m" from a calibration data set and individual survey data file inputs β, γ, and δ to output X, ϕ, and ψ for each survey. The following equations were used to solve for X, ϕ, and ψ.

$[X]=[c]*[C]$ where 'C' is the Mach calibration coefficient for the probe and 'c' is a scaling constant for the given conditions

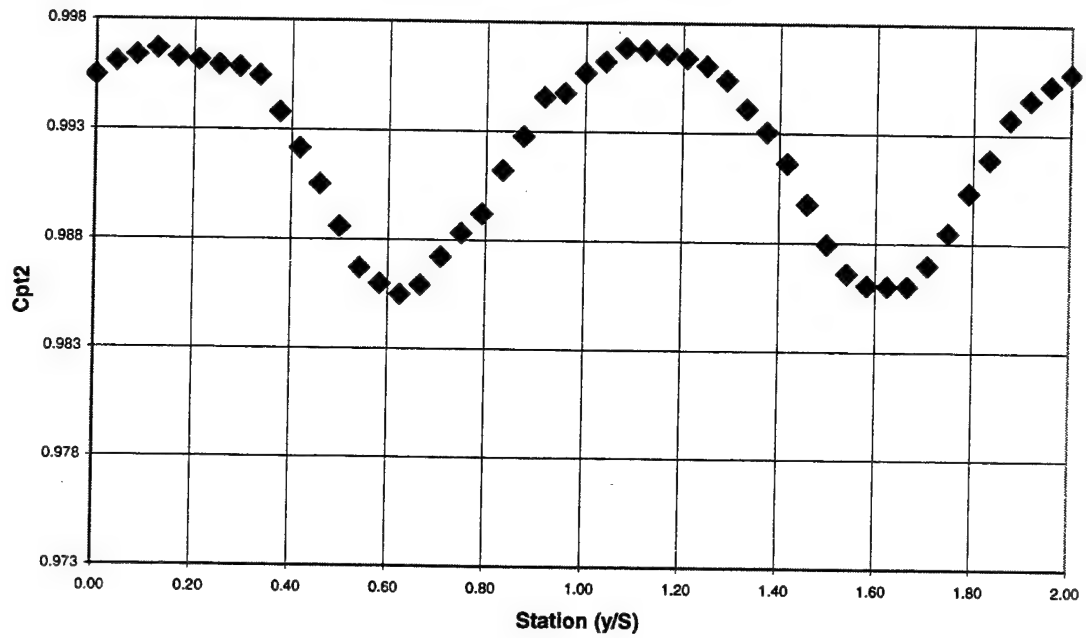
$[\phi]=[d]*[D]$ where 'D' is the Pitch calibration coefficient for the probe and 'd' is a scaling constant for the given conditions

$[\varphi]=[e]*[E]$ where 'E' is the Yaw calibration coefficient for the probe and 'e' is a scaling constant for the given conditions

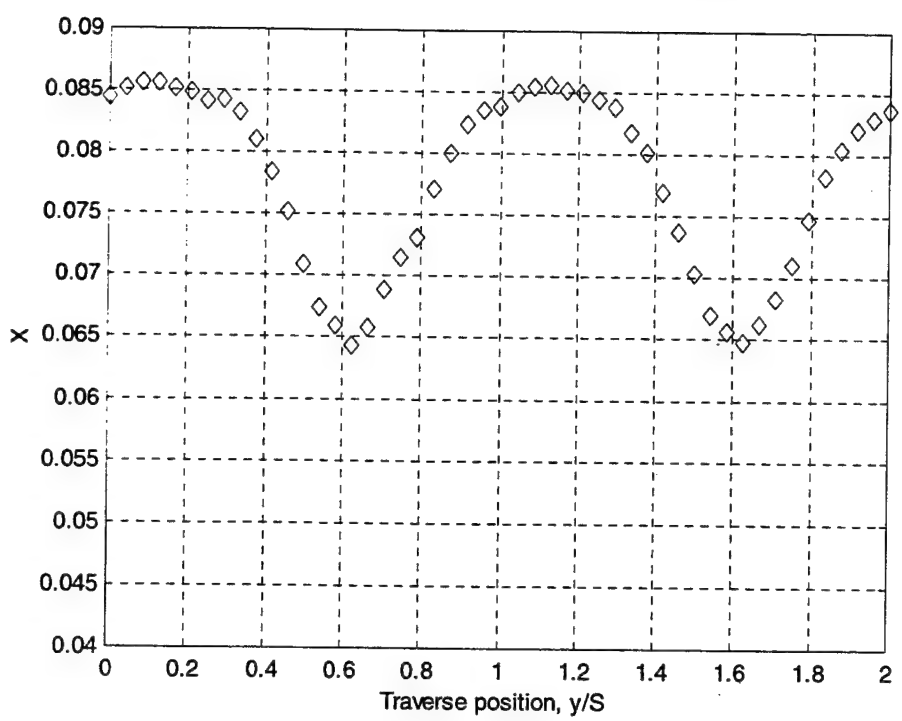
APPENDIX B: FIVE-HOLE PROBE PLOTS

Survey 1 (spanwise location 1)

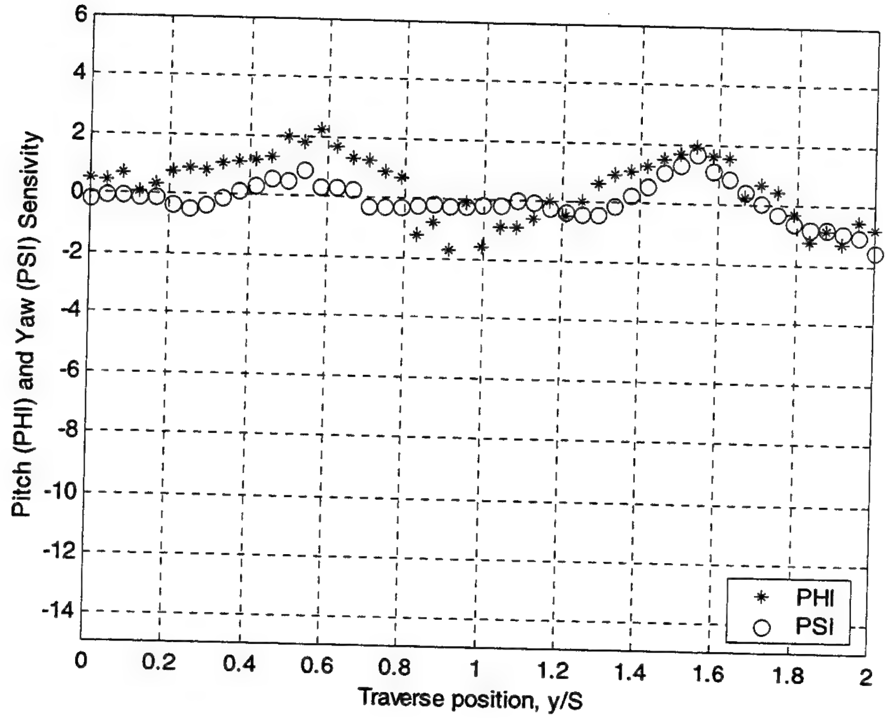
Stagnation Pressure Profile



Non-dimensional Velocity Distribution

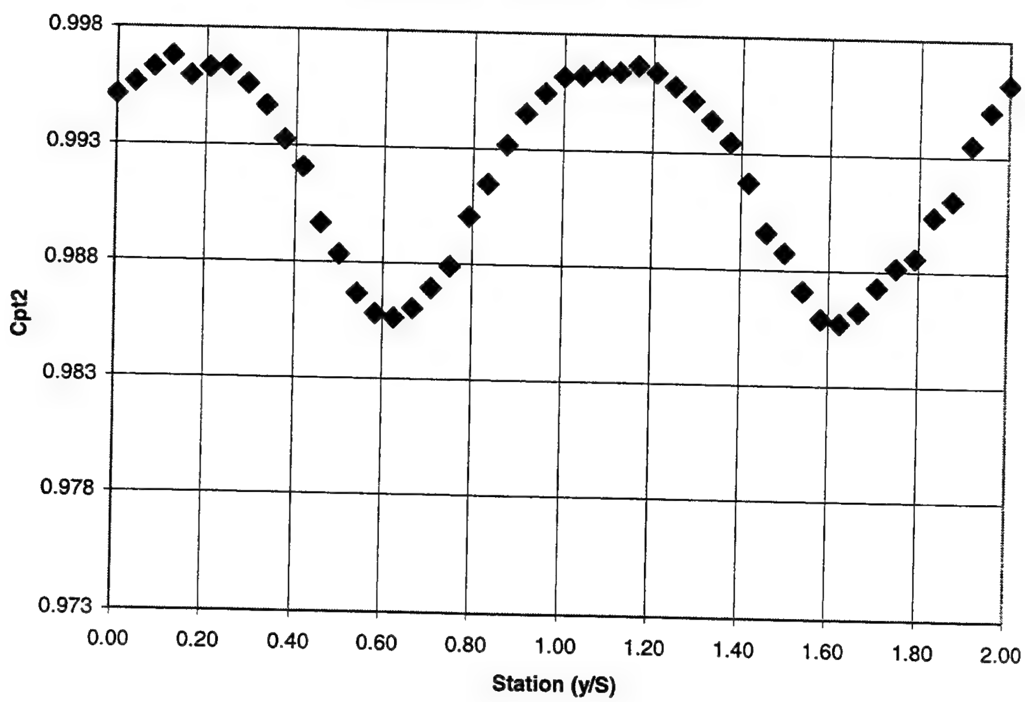


Pitch and Yaw Sensitivity Profile

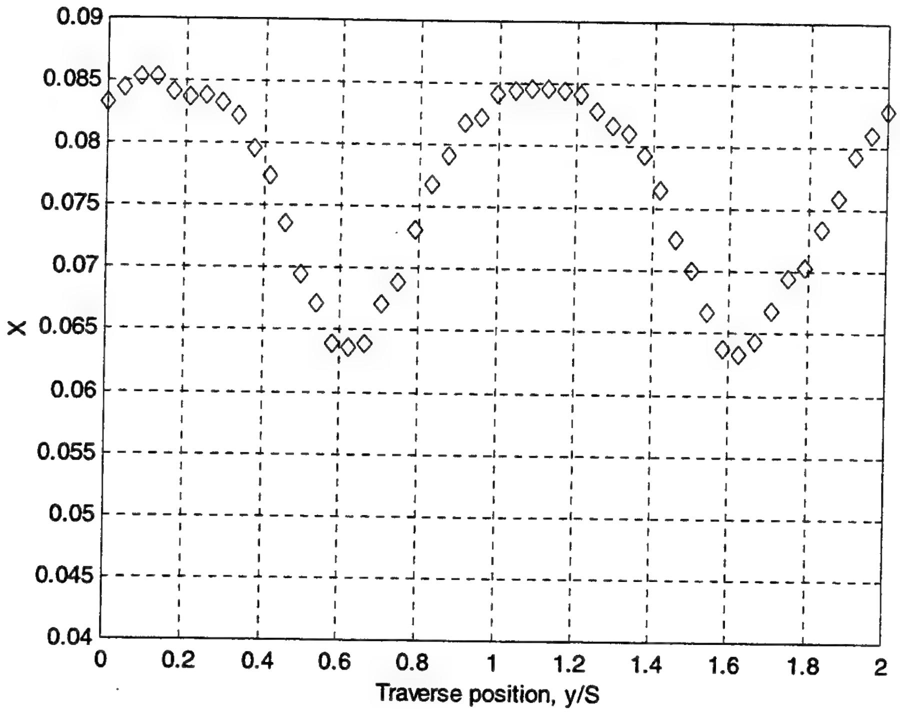


Survey 2 (spanwise location 2)

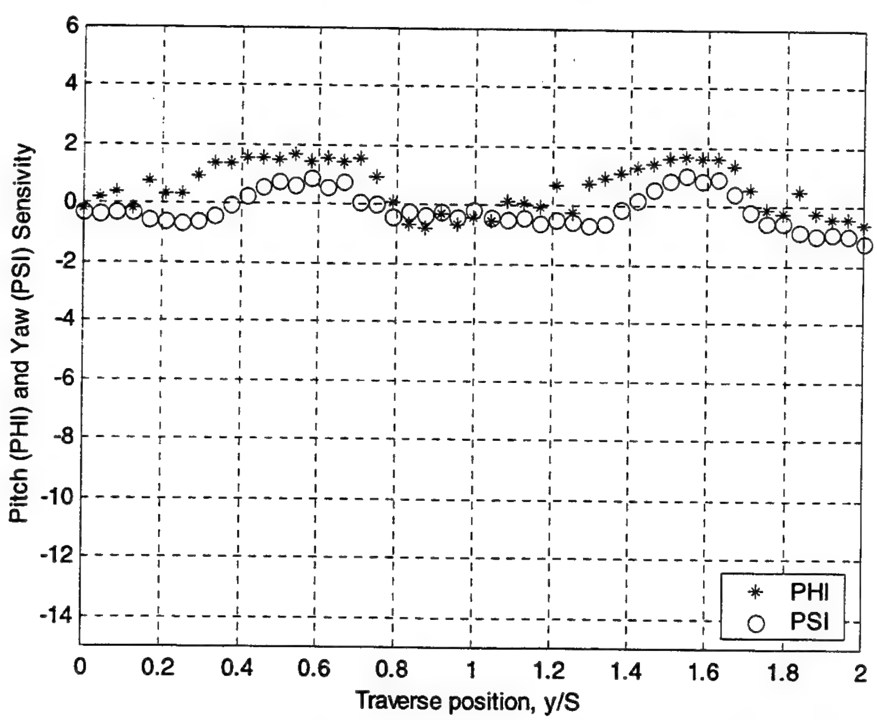
Stagnation Pressure Profile



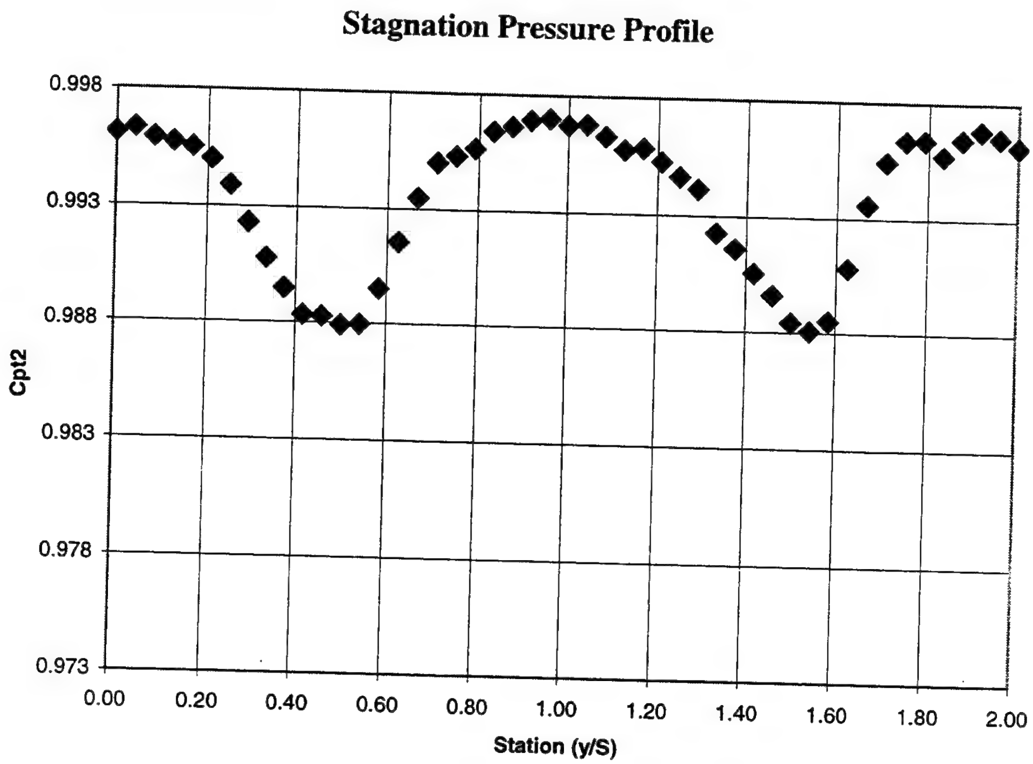
Non-dimensional Velocity Distribution

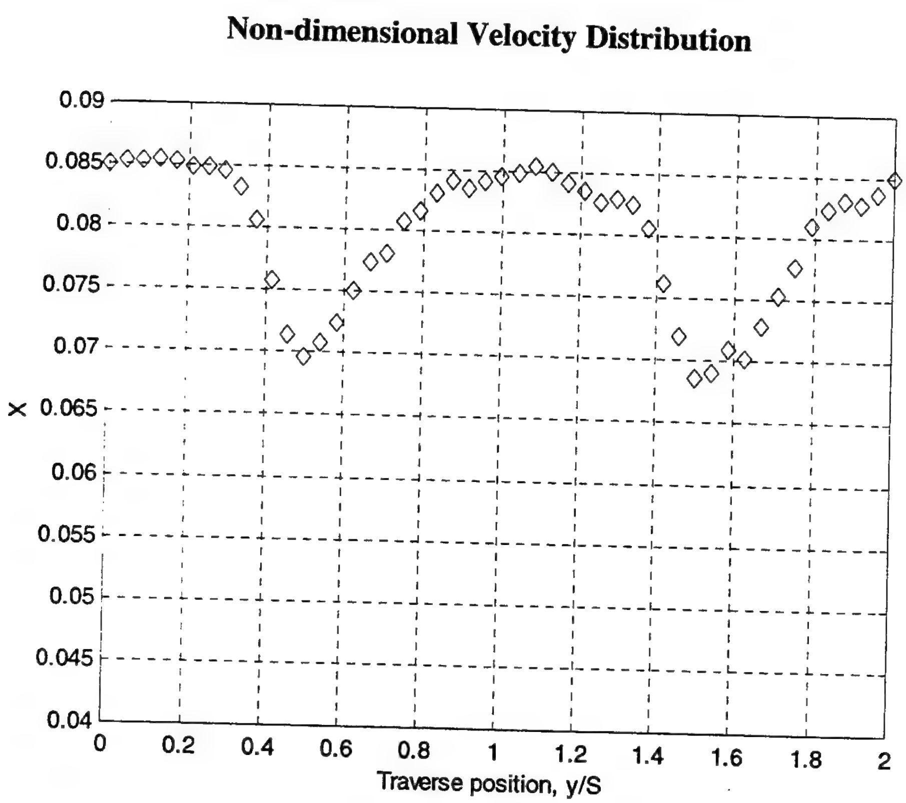


Pitch and Yaw Sensitivity Profile

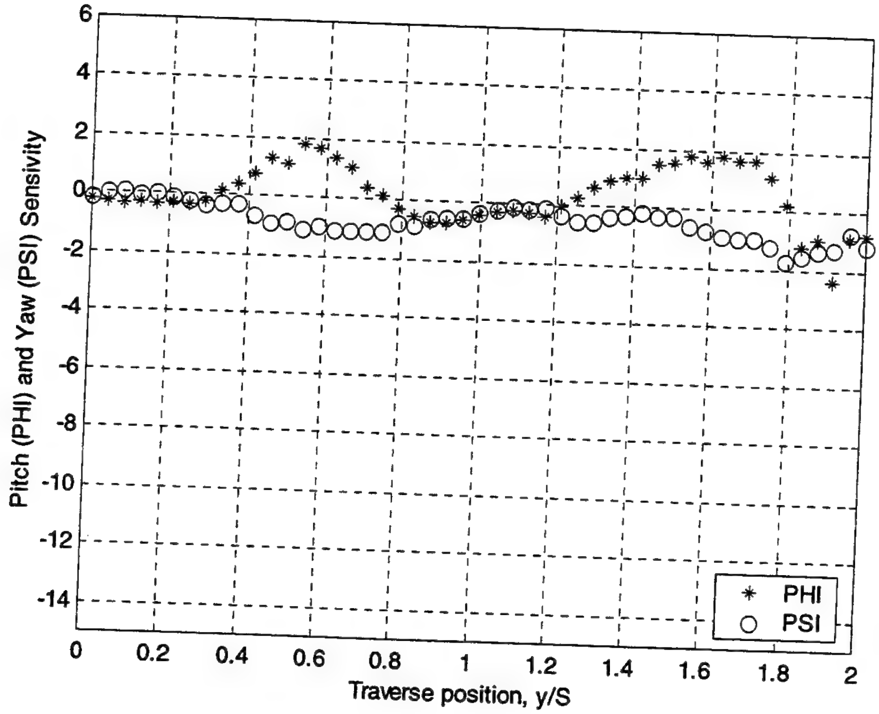


Survey 3 (spanwise location 3)



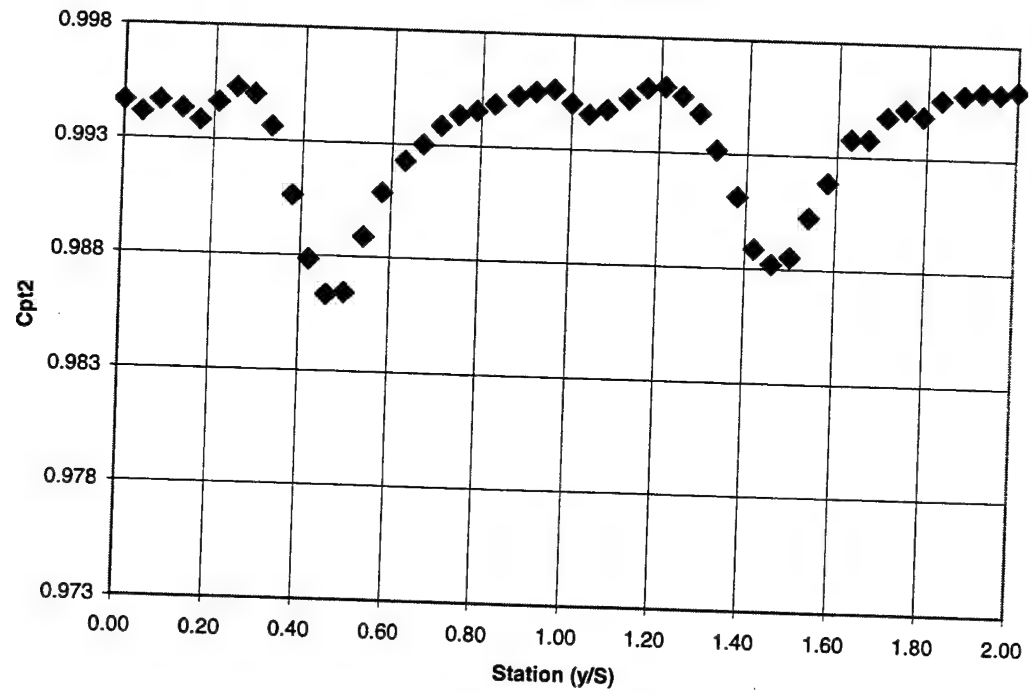


Pitch and Yaw Sensitivity Profile

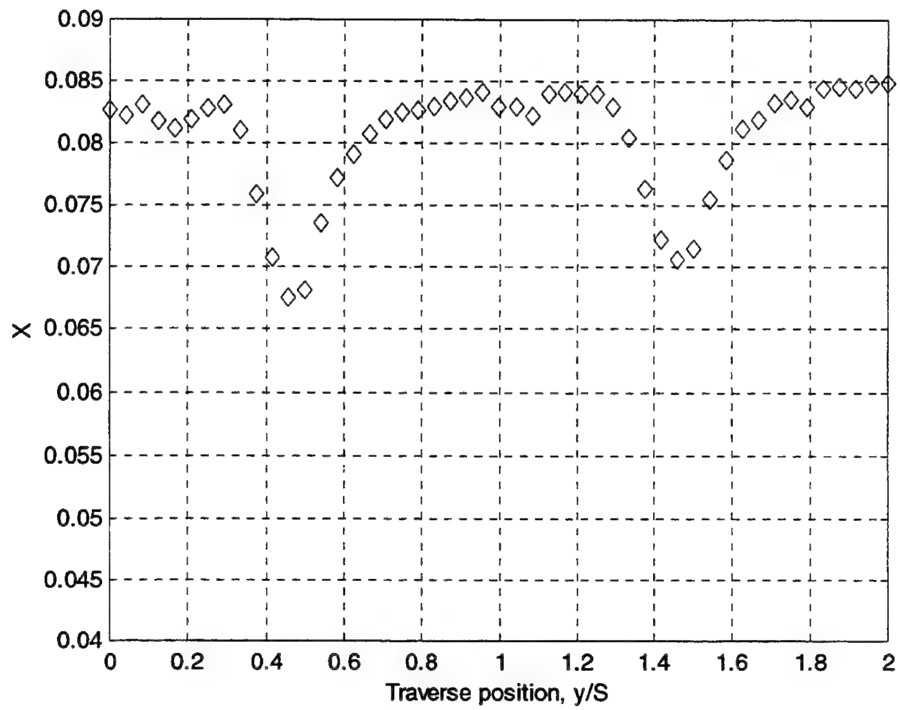


Survey 4 (spanwise location 4)

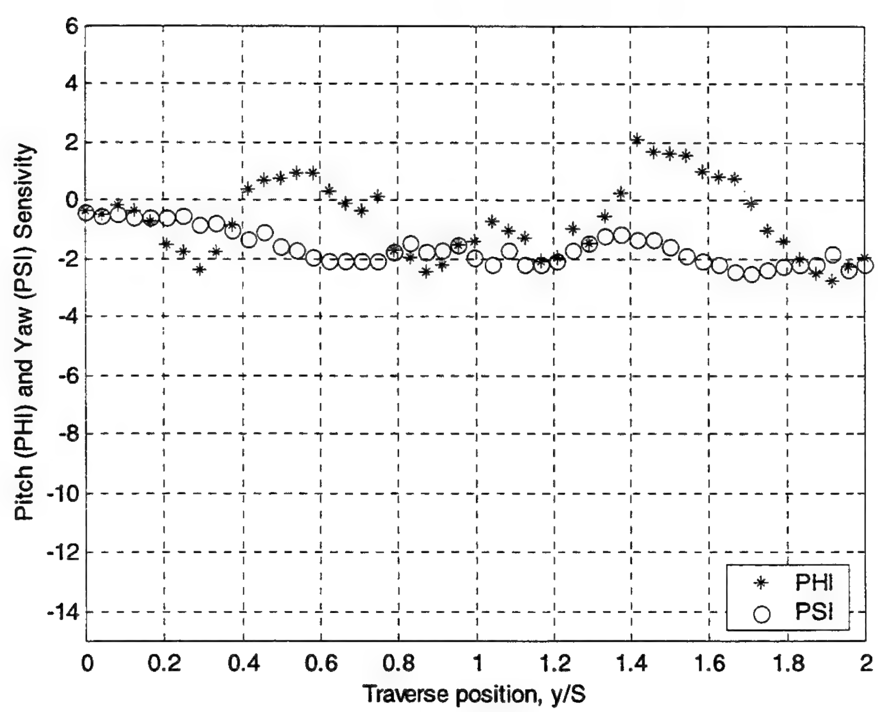
Stagnation Pressure Profile



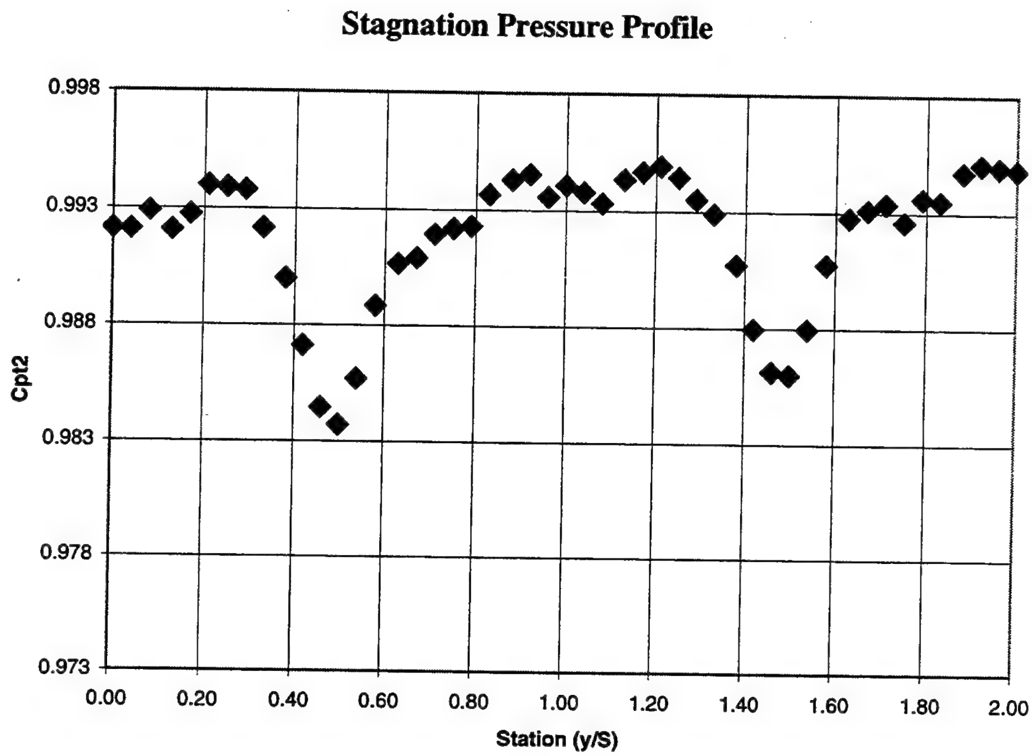
Non-dimensional Velocity Distribution

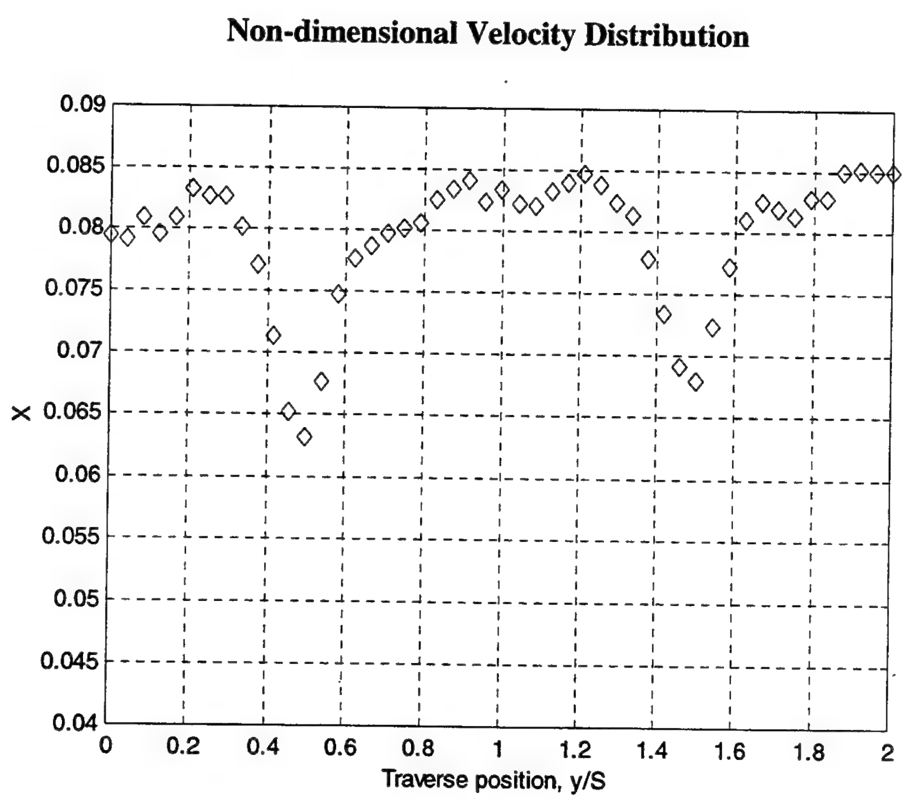


Pitch and Yaw Sensitivity Profile

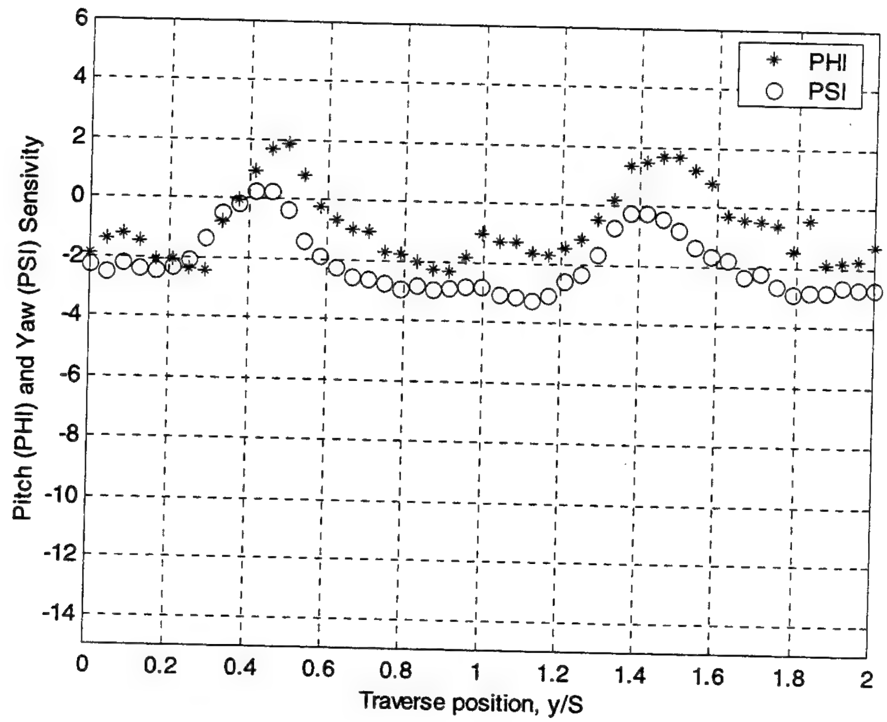


Survey 5 (spanwise location 5)



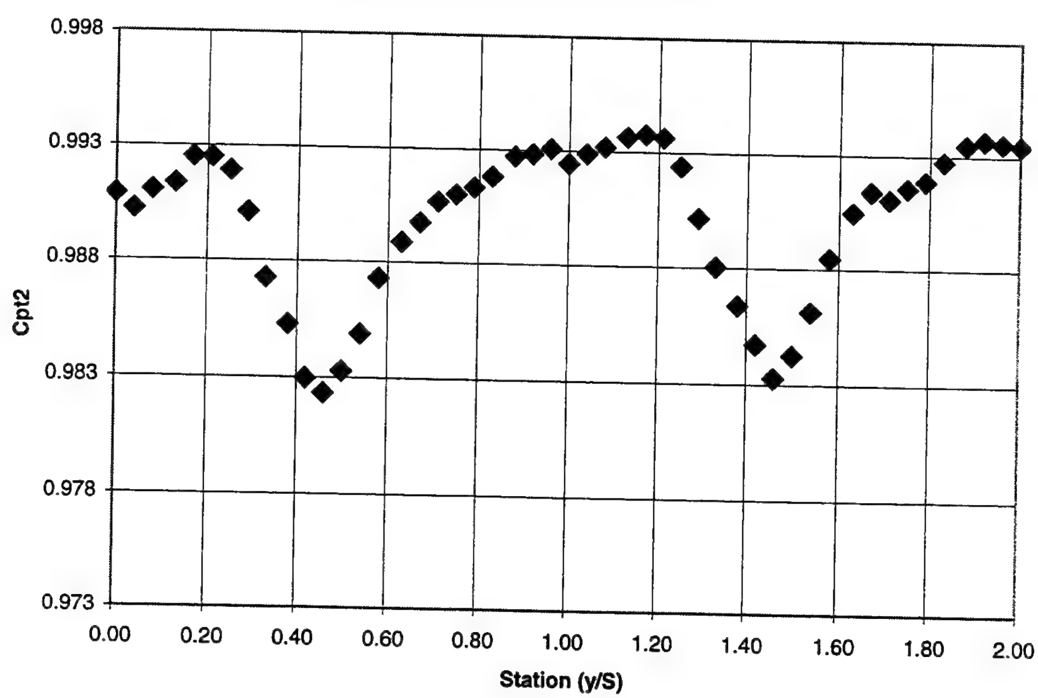


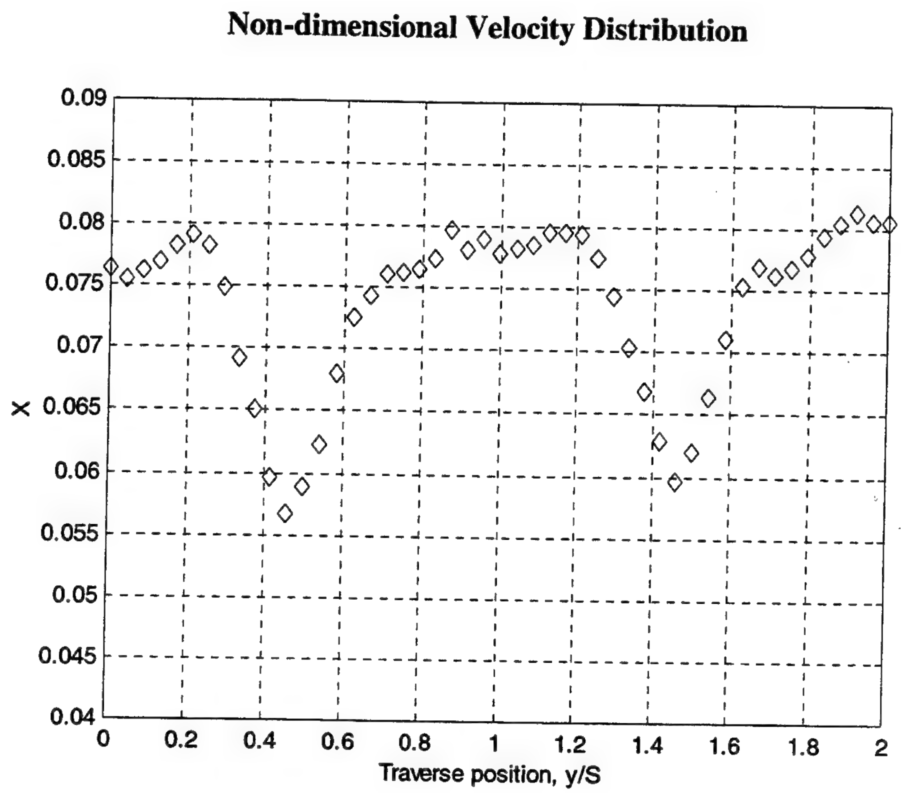
Pitch and Yaw Sensitivity Profile

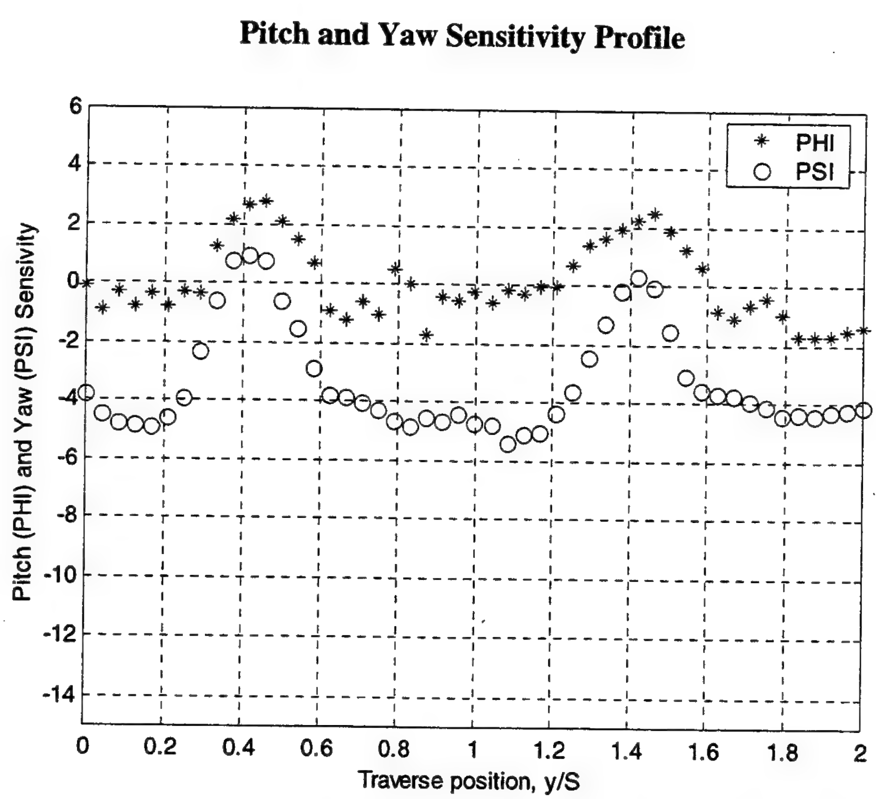


Survey 6 (spanwise location 6)

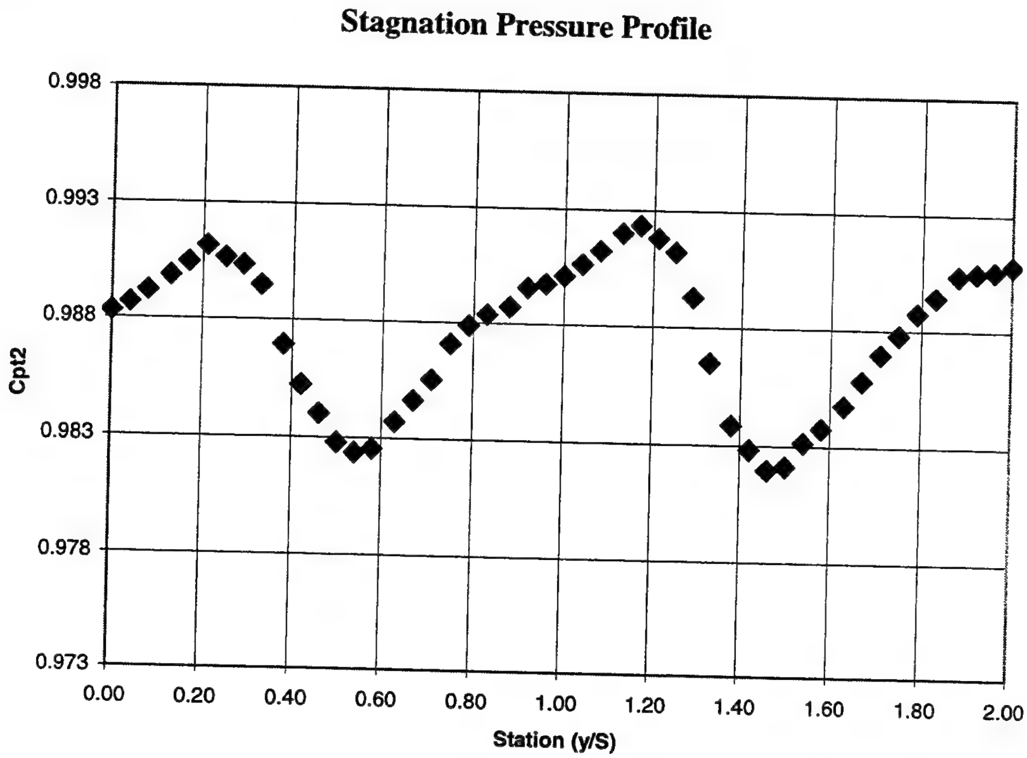
Stagnation Pressure Profile

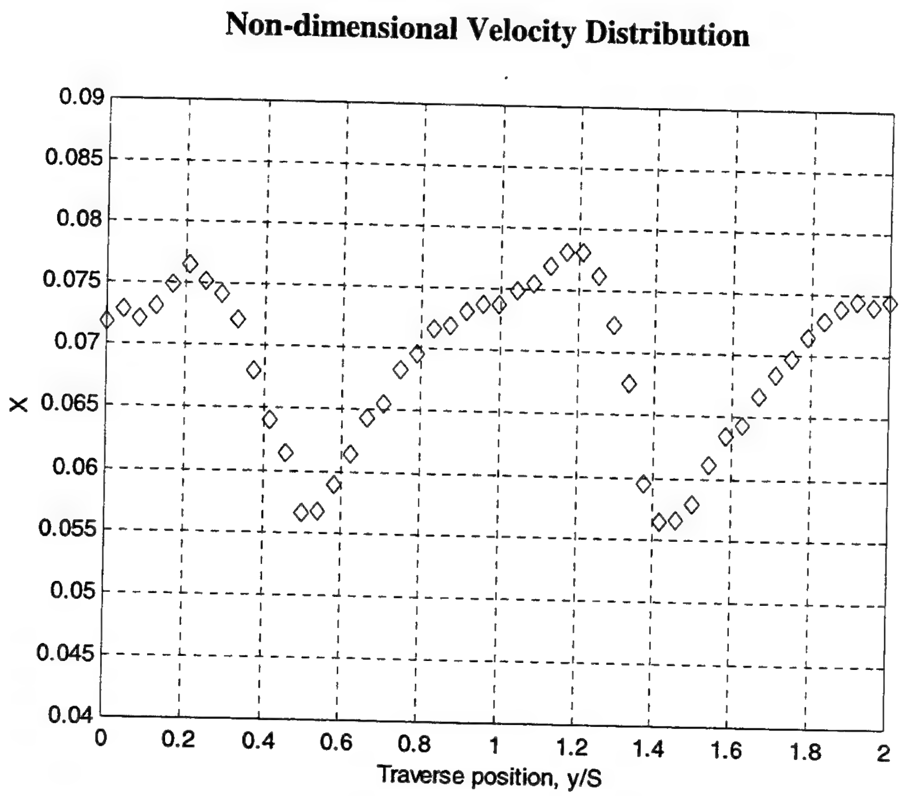



Non-dimensional Velocity Distribution
X
Traverse position, y/S
0.09
0.085
0.08
0.075
0.07
0.065
0.06
0.055
0.05
0.045
0.04
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

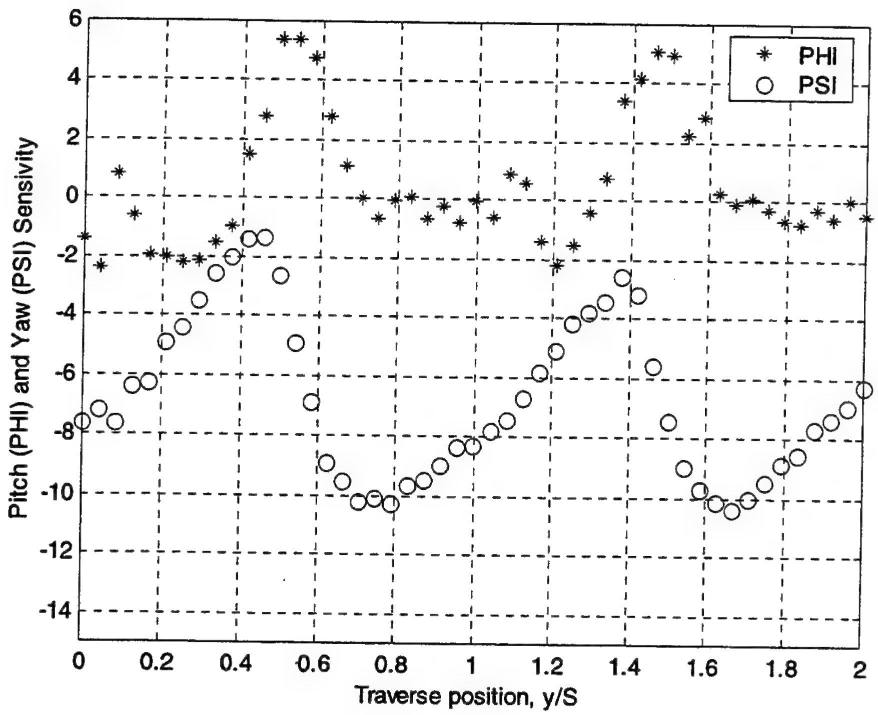

Pitch and Yaw Sensitivity Profile
PHI
PSI
Pitch (PHI) and Yaw (PSI) Sensivity
Traverse position, y/S
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

Survey 7 (spanwise location 7)



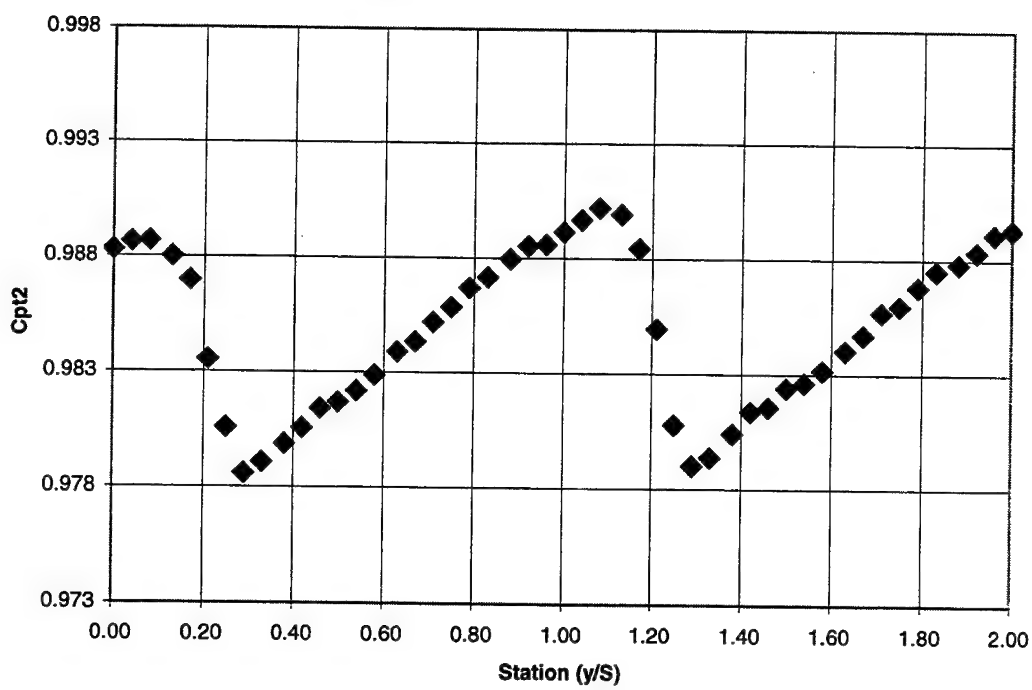


Pitch and Yaw Sensitivity Profile

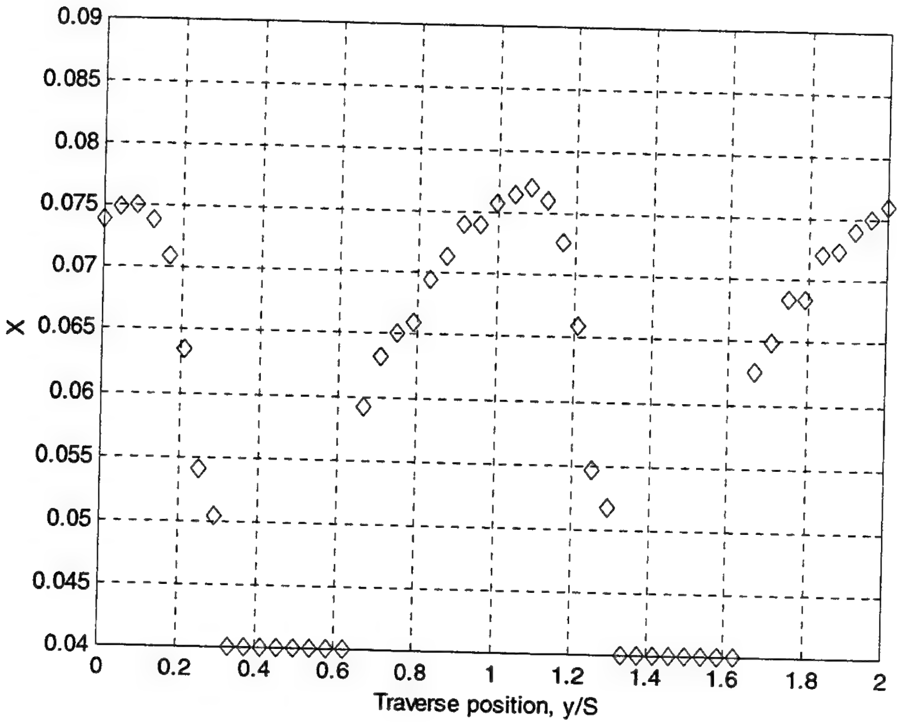


Survey 8 (spanwise location 8)

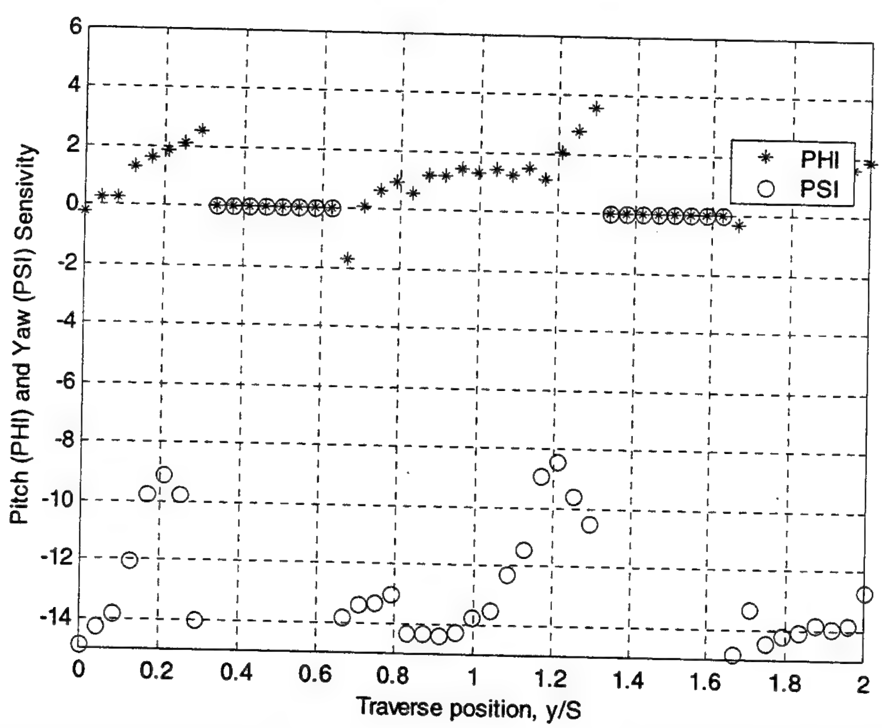
Stagnation Pressure Profile



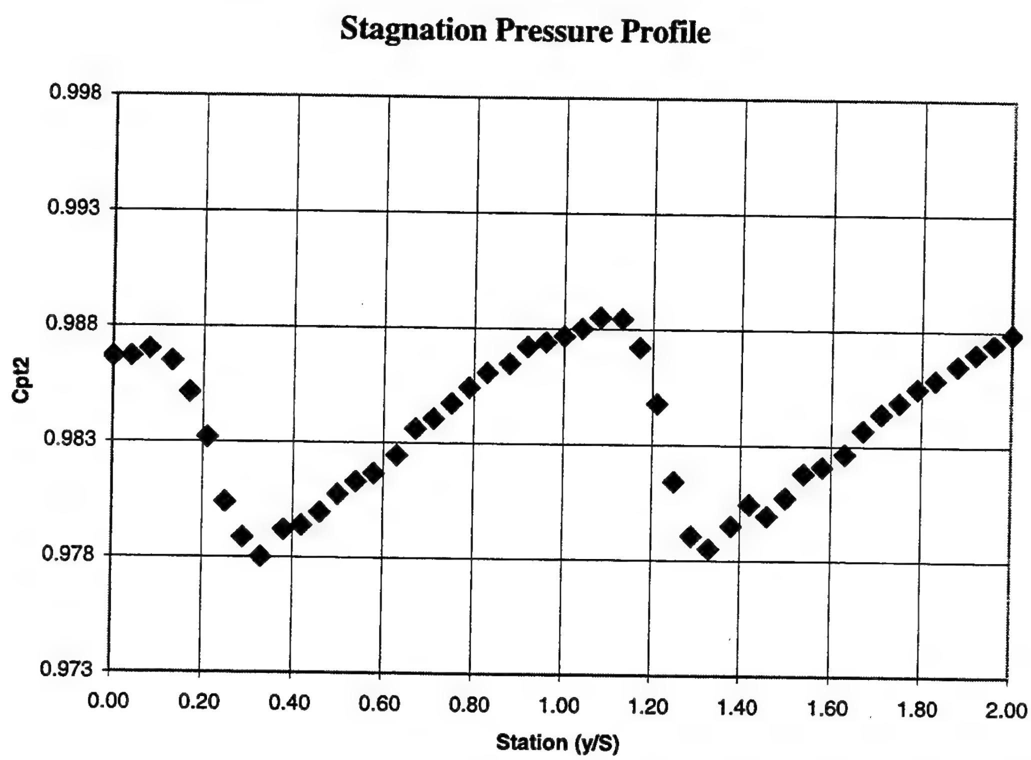
Non-dimensional Velocity Distribution

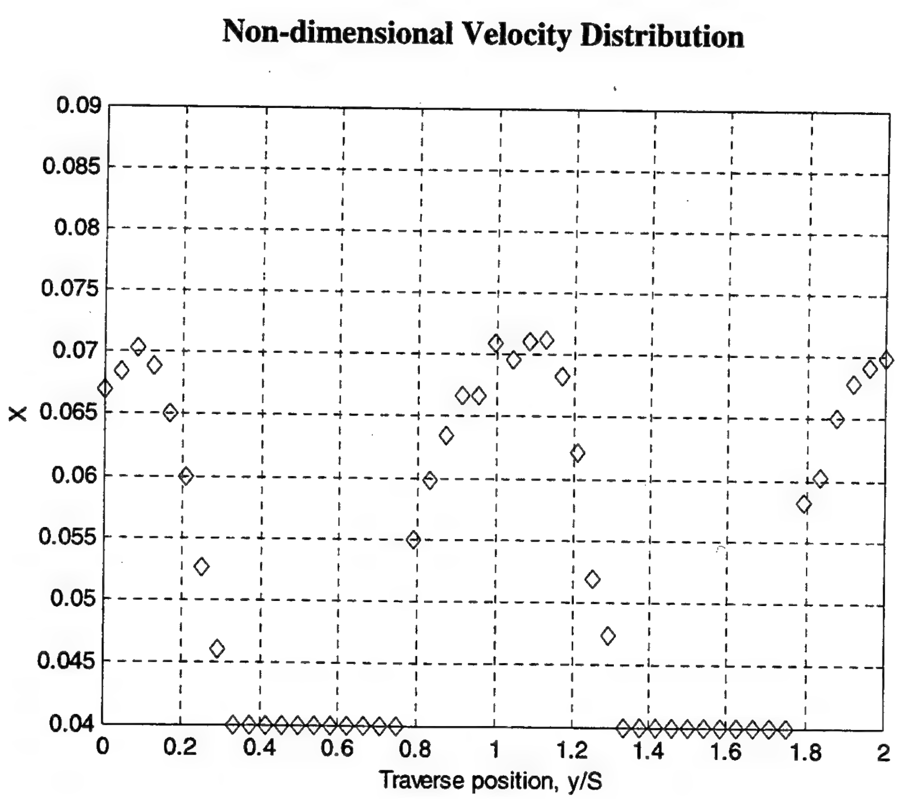


Pitch and Yaw Sensitivity Profile

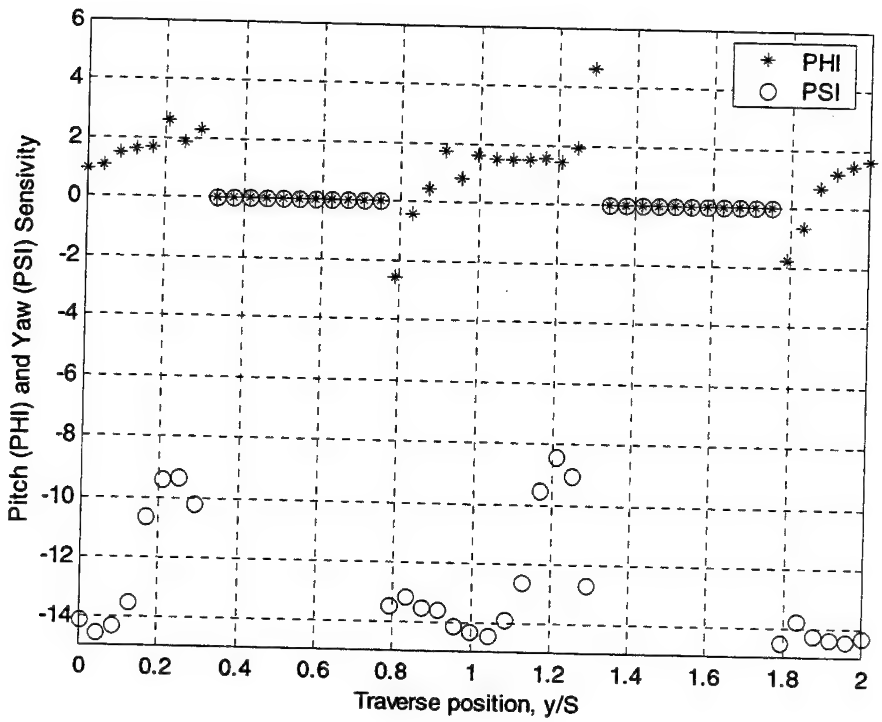


Survey 9 (spanwise location 9)

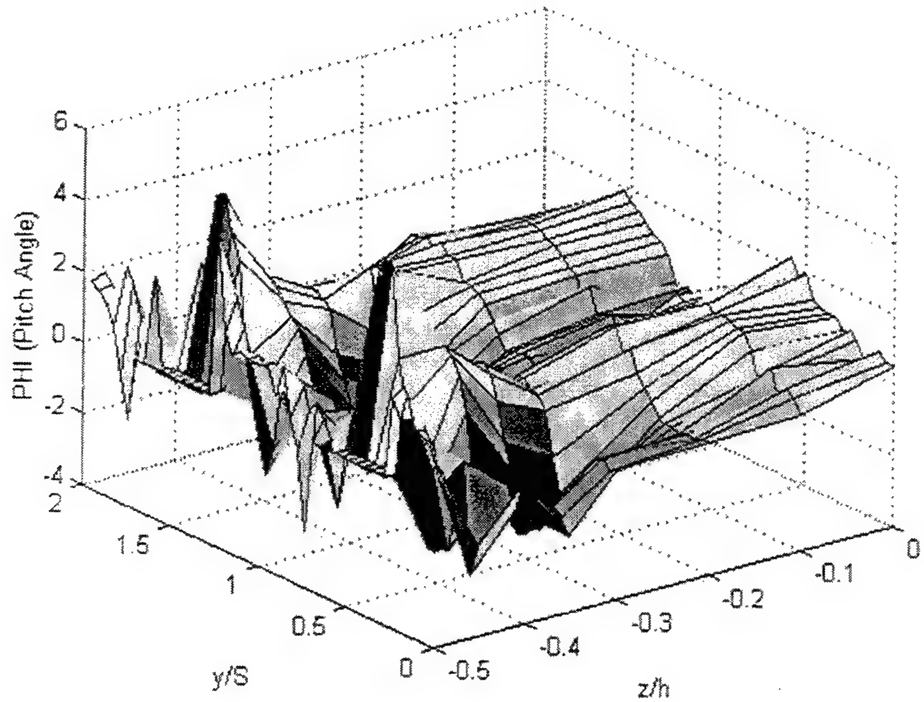




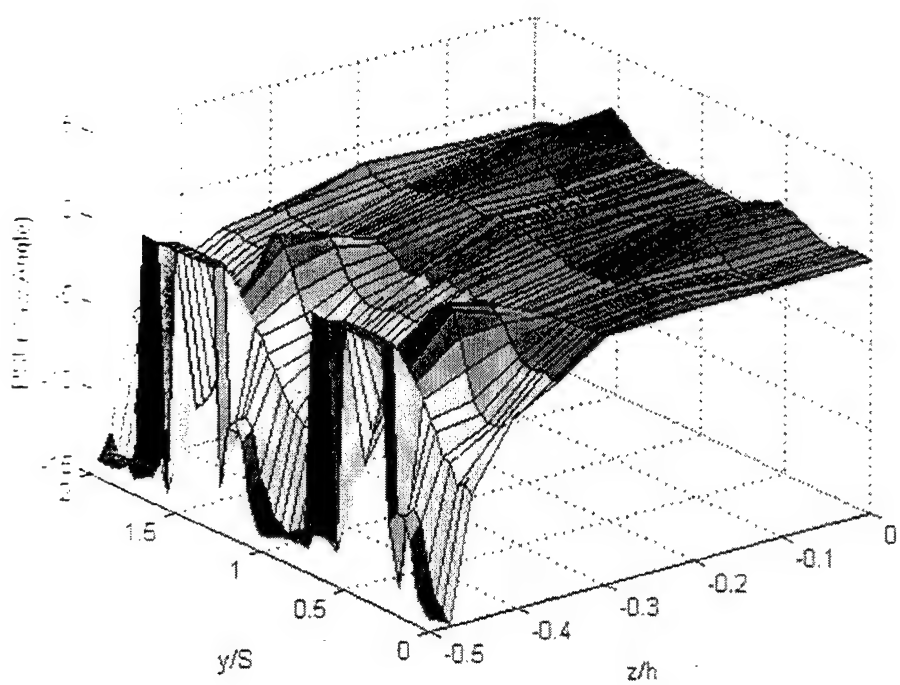
Pitch and Yaw Sensitivity Profile



Surface Plot of PHI



Surface Plot of PSI



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APPENDIX C: FIVE-HOLE PROBE DATA

Survey 1

Five-hole Probe Experiment - Reduced Data — Survey #1 03/18/00

y/S	Cpt1	Cpt2	Cps1	P1	P2	P3	P4	P5	Pavg	Beta	Gamma	Delta	X	PHI	PSI
0.000	0.996	0.995	0.964	421.157	410.885	410.931	411.222	410.976	411.004	0.024	0.024	-0.005	0.084	0.493	-0.148
0.042	0.996	0.996	0.965	421.391	410.899	410.995	411.271	411.017	411.046	0.025	0.025	-0.009	0.085	0.483	-0.041
0.083	0.996	0.996	0.965	421.555	410.919	411.007	411.321	411.163	411.103	0.025	0.015	-0.008	0.086	0.714	-0.046
0.125	0.996	0.997	0.965	421.634	411.031	411.074	411.447	411.023	411.144	0.025	0.040	-0.004	0.086	0.114	-0.116
0.167	0.996	0.996	0.964	421.499	411.014	411.075	411.380	411.054	411.131	0.025	0.031	-0.006	0.085	0.320	-0.100
0.208	0.996	0.996	0.964	421.478	411.080	411.014	411.428	411.300	411.205	0.024	0.012	0.006	0.085	0.784	-0.336
0.250	0.996	0.996	0.965	421.336	411.162	411.029	411.481	411.406	411.270	0.024	0.007	0.013	0.084	0.911	-0.489
0.292	0.996	0.996	0.965	421.331	411.078	411.018	411.403	411.292	411.198	0.024	0.011	0.006	0.084	0.824	-0.346
0.333	0.996	0.995	0.965	421.020	410.993	411.075	411.298	411.293	411.165	0.023	0.001	-0.008	0.083	1.103	-0.106
0.375	0.996	0.994	0.964	420.426	410.881	411.086	411.181	411.169	411.079	0.022	0.001	-0.022	0.081	1.130	0.142
0.417	0.996	0.992	0.965	419.728	410.781	411.040	411.053	411.042	410.979	0.021	0.001	-0.030	0.078	1.197	0.307
0.458	0.996	0.991	0.965	419.038	410.722	411.047	411.077	411.066	410.978	0.019	0.001	-0.040	0.075	1.292	0.597
0.500	0.996	0.989	0.965	418.174	410.815	411.048	410.912	411.033	410.952	0.017	-0.017	-0.032	0.071	1.980	0.499
0.542	0.996	0.987	0.964	417.533	410.726	411.008	410.996	411.047	410.944	0.016	-0.008	-0.043	0.068	1.825	0.889
0.583	0.996	0.986	0.964	417.253	410.814	410.911	410.963	411.083	410.943	0.015	-0.019	-0.015	0.066	2.220	0.305
0.625	0.996	0.985	0.964	416.984	410.830	410.901	411.051	411.048	410.958	0.014	0.000	-0.012	0.064	1.675	0.333
0.667	0.996	0.986	0.964	417.204	410.808	410.889	411.038	410.977	410.928	0.015	0.010	-0.013	0.066	1.335	0.283
0.708	0.996	0.987	0.964	417.791	410.859	410.830	411.107	411.054	410.963	0.016	0.008	0.004	0.069	1.273	-0.270
0.750	0.996	0.988	0.964	418.274	410.842	410.834	411.116	410.989	410.945	0.018	0.017	0.001	0.072	0.901	-0.286
0.792	0.996	0.989	0.964	418.647	410.873	410.888	411.181	411.002	410.986	0.018	0.023	-0.002	0.073	0.678	-0.254
0.833	0.996	0.991	0.964	419.555	410.890	410.919	411.395	410.600	410.951	0.021	0.092	-0.003	0.077	-1.196	-0.227
0.875	0.996	0.993	0.964	420.344	410.912	410.975	411.630	410.941	411.115	0.022	0.075	-0.007	0.080	-0.757	-0.147
0.917	0.996	0.995	0.964	420.976	411.004	411.006	411.690	410.490	411.048	0.024	0.121	0.000	0.082	-1.696	-0.195
0.958	0.996	0.995	0.964	421.155	411.086	411.084	411.437	410.953	411.140	0.024	0.048	0.000	0.084	-0.085	-0.243
1.000	0.996	0.996	0.964	421.463	411.144	411.166	411.829	410.624	411.191	0.024	0.117	-0.002	0.084	-1.582	-0.129
1.042	0.996	0.996	0.964	421.755	411.178	411.188	411.826	410.912	411.276	0.025	0.087	-0.001	0.085	-0.924	-0.151
1.083	0.996	0.997	0.964	421.894	411.164	411.258	411.870	410.957	411.312	0.025	0.086	-0.009	0.086	-0.915	0.000
1.125	0.996	0.997	0.964	421.902	411.191	411.266	411.828	411.085	411.343	0.025	0.070	-0.007	0.086	-0.566	-0.043
1.167	0.996	0.997	0.964	421.790	411.254	411.234	411.798	411.344	411.408	0.025	0.044	0.002	0.085	0.041	-0.235
1.208	0.996	0.996	0.964	421.740	411.285	411.181	411.786	411.090	411.336	0.025	0.067	0.010	0.085	-0.464	-0.364
1.250	0.996	0.996	0.964	421.604	411.284	411.171	411.766	411.313	411.384	0.024	0.044	0.011	0.084	0.033	-0.418
1.292	0.996	0.995	0.964	421.446	411.242	411.162	411.728	411.553	411.421	0.024	0.018	0.008	0.084	0.664	-0.397
1.333	0.996	0.994	0.964	420.858	411.123	411.227	411.575	411.499	411.356	0.023	0.008	-0.011	0.082	0.928	-0.080
1.375	0.996	0.993	0.964	420.437	410.988	411.258	411.464	411.418	411.282	0.022	0.005	-0.029	0.080	1.050	0.300
1.417	0.996	0.992	0.964	419.662	410.902	411.255	411.333	411.331	411.205	0.020	0.000	-0.042	0.077	1.276	0.599
1.458	0.996	0.990	0.964	418.938	410.826	411.293	411.229	411.254	411.151	0.019	-0.003	-0.060	0.074	1.494	1.102
1.500	0.996	0.988	0.964	418.262	410.806	411.265	411.181	411.225	411.119	0.017	-0.006	-0.064	0.070	1.691	1.304
1.542	0.996	0.987	0.964	417.642	410.796	411.283	411.172	411.236	411.122	0.016	-0.010	-0.075	0.067	1.912	1.682
1.583	0.996	0.986	0.964	417.419	410.878	411.178	411.239	411.237	411.133	0.015	0.000	-0.048	0.066	1.632	1.106
1.625	0.996	0.986	0.965	417.267	410.925	411.152	411.241	411.218	411.134	0.015	0.004	-0.037	0.065	1.556	0.900
1.667	0.996	0.986	0.964	417.437	410.933	411.062	411.221	410.943	411.040	0.015	0.043	-0.020	0.066	0.285	0.453
1.708	0.996	0.987	0.964	417.829	410.953	411.022	411.278	411.099	411.088	0.016	0.027	-0.010	0.068	0.730	0.099
1.750	0.996	0.988	0.964	418.413	411.004	410.993	411.394	411.150	411.135	0.017	0.034	0.002	0.071	0.437	-0.286
1.792	0.996	0.990	0.964	419.174	411.058	410.960	411.482	411.032	411.133	0.019	0.056	0.012	0.075	-0.256	-0.591
1.833	0.996	0.992	0.964	419.983	411.151	410.941	411.582	410.738	411.103	0.021	0.095	0.024	0.078	-1.190	-0.788
1.875	0.996	0.994	0.964	420.569	411.226	410.980	411.712	410.960	411.220	0.022	0.080	0.026	0.081	-0.819	-0.795
1.917	0.996	0.995	0.964	421.035	411.339	410.980	411.824	410.806	411.237	0.023	0.104	0.037	0.082	-1.263	-0.914
1.958	0.996	0.995	0.964	421.323	411.466	411.029	411.864	411.170	411.382	0.024	0.070	0.044	0.083	-0.505	-1.026
2.000	0.996	0.996	0.964	421.553	411.653	410.879	411.925	411.047	411.376	0.024	0.086	0.076	0.084	-0.784	-1.509

Survey 2

Five-hole Probe Experiment - Reduced Data

Survey #2 03/25/00

y/S	Cpt1	Cpt2	Cps1	P1	P2	P3	P4	P5	Pavg	Beta	Gamma	Delta	X	PHI	PSI
0.000	0.996	0.995	0.965	421.210	411.144	411.133	411.673	411.158	411.277	0.024	0.052	0.001	0.083	-0.170	-0.266
0.042	0.996	0.996	0.964	421.552	411.229	411.159	411.720	411.344	411.363	0.024	0.037	0.007	0.084	0.199	-0.349
0.083	0.996	0.996	0.965	421.692	411.247	411.215	411.473	411.169	411.276	0.025	0.029	0.003	0.085	0.382	-0.254
0.125	0.996	0.997	0.965	421.768	411.302	411.245	411.660	411.113	411.330	0.025	0.052	0.005	0.085	-0.148	-0.287
0.167	0.996	0.996	0.965	421.542	411.361	411.217	411.677	411.548	411.451	0.024	0.013	0.014	0.084	0.780	-0.503
0.208	0.996	0.996	0.965	421.463	411.403	411.231	411.735	411.407	411.444	0.024	0.033	0.017	0.084	0.305	-0.559
0.250	0.996	0.996	0.965	421.480	411.416	411.194	411.692	411.373	411.419	0.024	0.032	0.022	0.084	0.335	-0.642
0.292	0.996	0.996	0.965	421.314	411.386	411.200	411.611	411.552	411.437	0.023	0.006	0.019	0.083	0.951	-0.618
0.333	0.996	0.995	0.965	420.963	411.242	411.191	411.493	411.581	411.377	0.023	-0.009	0.005	0.082	1.366	-0.397
0.375	0.996	0.993	0.965	420.267	411.121	411.249	411.299	411.362	411.258	0.021	-0.007	-0.014	0.080	1.386	-0.029
0.417	0.996	0.992	0.965	419.749	411.005	411.245	411.280	411.362	411.223	0.020	-0.010	-0.028	0.077	1.541	0.282
0.458	0.996	0.990	0.965	418.854	410.891	411.192	411.170	411.216	411.117	0.018	-0.006	-0.039	0.074	1.561	0.593
0.500	0.996	0.988	0.965	418.073	410.898	411.175	411.200	411.205	411.119	0.017	-0.001	-0.040	0.070	1.535	0.748
0.542	0.996	0.987	0.965	417.618	410.922	411.133	411.170	411.195	411.105	0.016	-0.004	-0.032	0.067	1.714	0.667
0.583	0.996	0.986	0.965	417.049	410.930	411.137	411.155	411.110	411.083	0.014	0.008	-0.035	0.064	1.473	0.912
0.625	0.996	0.986	0.965	417.069	410.999	411.114	411.247	411.215	411.144	0.014	0.005	-0.019	0.064	1.546	0.558
0.667	0.996	0.986	0.965	417.117	410.938	411.110	411.266	411.218	411.133	0.014	0.008	-0.029	0.064	1.453	0.764
0.708	0.996	0.987	0.965	417.674	410.982	411.036	411.288	411.290	411.149	0.016	0.000	-0.008	0.067	1.593	0.097
0.750	0.996	0.988	0.965	417.981	410.971	411.030	411.322	411.192	411.129	0.016	0.019	-0.009	0.069	0.939	0.032
0.792	0.996	0.990	0.965	418.817	411.043	411.009	411.406	411.068	411.132	0.018	0.044	0.004	0.073	0.094	-0.400
0.833	0.996	0.991	0.965	419.592	411.048	411.077	411.441	410.850	411.104	0.020	0.070	-0.003	0.077	-0.638	-0.242
0.875	0.996	0.993	0.965	420.187	411.103	411.088	411.523	410.827	411.135	0.022	0.077	0.002	0.079	-0.799	-0.332
0.917	0.996	0.995	0.965	420.842	411.154	411.193	411.591	411.053	411.248	0.023	0.056	-0.004	0.082	-0.291	-0.195
0.958	0.997	0.995	0.965	421.042	411.271	411.203	411.700	410.987	411.290	0.023	0.073	0.007	0.082	-0.664	-0.383
1.000	0.996	0.996	0.965	421.490	411.255	411.281	411.688	411.068	411.323	0.024	0.061	-0.002	0.084	-0.377	-0.171
1.042	0.996	0.996	0.965	421.617	411.355	411.256	411.727	411.012	411.338	0.024	0.070	0.010	0.084	-0.536	-0.374
1.083	0.996	0.996	0.965	421.761	411.440	411.306	411.856	411.446	411.512	0.024	0.040	0.013	0.085	0.136	-0.451
1.125	0.996	0.996	0.965	421.711	411.421	411.302	411.791	411.350	411.466	0.024	0.043	0.012	0.085	0.063	-0.425
1.167	0.996	0.997	0.965	421.700	411.482	411.268	411.834	411.346	411.482	0.024	0.048	0.021	0.084	-0.032	-0.592
1.208	0.996	0.996	0.965	421.639	411.426	411.313	411.773	411.602	411.528	0.024	0.017	0.011	0.084	0.677	-0.445
1.250	0.997	0.996	0.965	421.309	411.467	411.322	411.788	411.261	411.460	0.023	0.053	0.015	0.083	-0.192	-0.529
1.292	0.996	0.995	0.965	421.030	411.451	411.268	411.765	411.635	411.530	0.023	0.014	0.019	0.082	0.777	-0.672
1.333	0.996	0.994	0.965	420.848	411.390	411.266	411.710	411.632	411.500	0.022	0.008	0.013	0.081	0.922	-0.573
1.375	0.996	0.993	0.965	420.328	411.203	411.293	411.563	411.541	411.400	0.021	0.002	-0.010	0.079	1.128	-0.122
1.417	0.996	0.992	0.965	419.656	411.072	411.277	411.442	411.457	411.312	0.020	-0.002	-0.025	0.077	1.332	0.209
1.458	0.996	0.990	0.965	418.787	410.991	411.273	411.359	411.359	411.246	0.018	0.000	-0.037	0.073	1.412	0.586
1.500	0.996	0.989	0.965	418.293	410.957	411.284	411.333	411.358	411.233	0.017	-0.004	-0.046	0.070	1.609	0.881
1.542	0.996	0.987	0.965	417.657	410.953	411.260	411.299	411.310	411.206	0.015	-0.002	-0.048	0.067	1.661	1.051
1.583	0.996	0.986	0.965	417.162	411.003	411.203	411.329	411.317	411.213	0.014	0.002	-0.034	0.064	1.651	0.878
1.625	0.996	0.986	0.965	417.080	410.993	411.202	411.315	411.293	411.201	0.014	0.004	-0.036	0.063	1.613	0.954
1.667	0.996	0.986	0.965	417.251	411.024	411.133	411.350	411.285	411.198	0.015	0.011	-0.018	0.064	1.358	0.483
1.708	0.996	0.987	0.965	417.699	411.107	411.084	411.432	411.222	411.211	0.016	0.032	0.004	0.067	0.596	-0.169
1.750	0.996	0.988	0.965	418.135	411.126	411.029	411.429	411.055	411.160	0.017	0.054	0.014	0.069	-0.101	-0.533
1.792	0.996	0.989	0.965	418.320	411.146	411.054	411.425	411.011	411.159	0.017	0.058	0.013	0.070	-0.239	-0.540
1.833	0.996	0.990	0.965	418.966	411.203	411.020	411.474	411.257	411.238	0.018	0.028	0.024	0.074	0.531	-0.834
1.875	0.996	0.991	0.965	419.484	411.225	410.986	411.541	411.086	411.209	0.020	0.055	0.029	0.076	-0.227	-0.951
1.917	0.996	0.994	0.965	420.389	411.390	411.117	411.750	411.178	411.359	0.021	0.063	0.030	0.079	-0.431	-0.916
1.958	0.996	0.995	0.965	420.892	411.480	411.153	411.875	411.275	411.446	0.022	0.064	0.035	0.081	-0.414	-0.946
2.000	0.997	0.996	0.965	421.421	411.687	411.129	411.943	411.205	411.491	0.024	0.074	0.056	0.083	-0.585	-1.235

Survey 3

Five-hole Probe Experiment - Reduced Data														Survey #3 03/29/00		
y/S	Cpt1	Cpt2	Cps1	P1	P2	P3	P4	P5	Pavg	Beta	Gamma	Delta	X	PHI	PSI	
0.000	0.996	0.996	0.964	421.875	411.717	411.223	411.839	410.916	411.424	0.025	0.088	0.047	0.085	-0.249	-0.179	
0.042	0.996	0.996	0.964	421.926	411.734	411.138	411.936	411.037	411.461	0.025	0.086	0.057	0.085	-0.254	-0.001	
0.083	0.996	0.996	0.964	421.739	411.666	411.368	412.115	411.233	411.595	0.024	0.087	0.029	0.085	-0.347	0.099	
0.125	0.996	0.996	0.964	421.581	411.595	410.996	412.368	410.684	411.411	0.024	0.166	0.059	0.086	-0.270	-0.009	
0.167	0.996	0.996	0.964	421.488	411.552	410.916	412.168	411.224	411.465	0.024	0.094	0.063	0.085	-0.365	0.043	
0.208	0.996	0.995	0.964	421.223	411.533	410.818	412.016	410.968	411.334	0.023	0.106	0.072	0.085	-0.303	-0.078	
0.250	0.996	0.994	0.964	420.819	411.492	410.765	411.854	411.494	411.401	0.022	0.038	0.077	0.085	-0.323	-0.251	
0.292	0.996	0.992	0.965	419.980	411.449	411.088	411.554	411.543	411.408	0.020	0.001	0.042	0.085	-0.242	-0.322	
0.333	0.996	0.991	0.965	419.422	411.369	411.137	411.401	411.511	411.354	0.019	-0.014	0.029	0.083	0.143	-0.279	
0.375	0.996	0.989	0.965	418.848	411.324	411.085	411.297	411.383	411.273	0.018	-0.011	0.032	0.081	0.403	-0.263	
0.417	0.996	0.988	0.965	418.319	411.325	411.108	411.258	411.341	411.258	0.017	-0.012	0.031	0.076	0.735	-0.632	
0.458	0.995	0.988	0.965	418.322	411.174	411.018	411.099	411.150	411.110	0.017	-0.007	0.022	0.071	1.333	-0.888	
0.500	0.996	0.988	0.965	418.166	411.335	411.208	411.308	411.384	411.309	0.016	-0.011	0.019	0.070	1.154	-0.831	
0.542	0.995	0.988	0.965	418.189	411.416	411.372	411.411	411.421	411.405	0.016	-0.001	0.006	0.071	1.803	-1.062	
0.583	0.996	0.990	0.965	418.749	411.294	411.290	411.355	411.387	411.332	0.018	-0.004	0.001	0.072	1.661	-0.961	
0.625	0.996	0.992	0.964	419.684	411.369	411.426	411.457	411.382	411.409	0.020	0.009	-0.007	0.075	1.393	-1.052	
0.667	0.996	0.994	0.964	420.569	411.301	411.319	411.375	411.316	411.328	0.022	0.006	-0.002	0.077	1.068	-1.095	
0.708	0.996	0.995	0.965	421.163	411.405	411.367	411.585	411.492	411.462	0.023	0.010	0.004	0.078	0.393	-1.089	
0.750	0.996	0.995	0.964	421.332	411.554	411.409	411.664	411.483	411.528	0.023	0.018	0.015	0.081	0.153	-1.097	
0.792	0.996	0.996	0.965	421.352	411.572	411.426	411.836	411.509	411.586	0.023	0.033	0.015	0.082	-0.276	-0.794	
0.833	0.997	0.996	0.965	421.574	411.572	411.511	411.834	411.380	411.575	0.024	0.045	0.006	0.083	-0.519	-0.811	
0.875	0.997	0.997	0.965	421.682	411.468	411.536	411.805	411.181	411.498	0.024	0.061	-0.007	0.084	-0.703	-0.604	
0.917	0.997	0.997	0.965	421.847	411.397	411.415	411.790	411.188	411.448	0.025	0.058	-0.002	0.084	-0.715	-0.559	
0.958	0.996	0.997	0.965	421.923	411.345	411.388	411.753	411.163	411.412	0.025	0.056	-0.004	0.084	-0.600	-0.526	
1.000	0.996	0.997	0.965	421.759	411.359	411.330	411.768	411.166	411.406	0.025	0.058	0.003	0.085	-0.389	-0.361	
1.042	0.997	0.997	0.965	421.614	411.346	411.256	411.676	411.029	411.327	0.024	0.063	0.009	0.085	-0.288	-0.249	
1.083	0.996	0.996	0.965	421.633	411.456	411.273	411.844	411.098	411.418	0.024	0.073	0.018	0.086	-0.246	-0.109	
1.125	0.996	0.996	0.965	421.402	411.390	411.202	411.758	410.974	411.331	0.024	0.078	0.019	0.085	-0.289	-0.164	
1.167	0.996	0.996	0.965	421.441	411.273	411.042	411.679	410.878	411.218	0.024	0.078	0.023	0.084	-0.392	-0.094	
1.208	0.997	0.995	0.965	421.158	411.268	410.951	411.633	.410.939	411.198	0.024	0.070	0.032	0.084	-0.009	-0.356	
1.250	0.996	0.995	0.965	420.842	411.283	411.022	411.665	411.116	411.271	0.023	0.057	0.027	0.083	0.281	-0.552	
1.292	0.997	0.994	0.965	420.566	411.382	410.997	411.501	411.132	411.253	0.022	0.040	0.041	0.083	0.646	-0.551	
1.333	0.996	0.992	0.965	419.852	411.238	410.915	411.325	411.061	411.135	0.021	0.030	0.037	0.083	0.872	-0.359	
1.375	0.996	0.992	0.965	419.683	411.307	410.996	411.203	411.159	411.166	0.020	0.005	0.036	0.081	0.985	-0.277	
1.417	0.996	0.991	0.965	419.162	411.274	411.001	411.141	411.174	411.147	0.019	-0.004	0.034	0.076	1.012	-0.184	
1.458	0.997	0.990	0.965	418.656	411.266	411.034	411.154	411.231	411.171	0.018	-0.010	0.031	0.072	1.529	-0.285	
1.500	0.996	0.988	0.965	418.340	411.258	410.988	411.131	411.227	411.151	0.017	-0.013	0.038	0.069	1.560	-0.309	
1.542	0.996	0.988	0.965	418.120	411.253	411.060	411.195	411.123	411.158	0.017	0.010	0.028	0.069	1.823	-0.595	
1.583	0.996	0.989	0.964	418.418	411.210	411.003	411.156	411.139	411.127	0.017	0.002	0.028	0.071	1.629	-0.724	
1.625	0.996	0.991	0.965	419.307	411.157	411.045	411.245	411.089	411.134	0.019	0.019	0.014	0.070	1.788	-0.898	
1.667	0.996	0.994	0.965	420.455	411.115	411.136	411.369	411.105	411.181	0.022	0.028	-0.002	0.073	1.675	-0.978	
1.708	0.997	0.995	0.965	421.164	411.201	411.189	411.528	411.145	411.266	0.024	0.039	0.001	0.075	1.658	-0.945	
1.750	0.996	0.996	0.965	421.537	411.237	411.170	411.579	411.000	411.246	0.024	0.056	0.007	0.078	1.165	-1.203	
1.792	0.997	0.996	0.965	421.601	411.204	411.172	411.602	410.983	411.240	0.025	0.060	0.003	0.081	0.215	-1.703	
1.833	0.996	0.996	0.964	421.549	411.127	411.197	411.559	410.961	411.211	0.025	0.058	-0.007	0.082	-1.233	-1.525	
1.875	0.997	0.996	0.964	421.686	411.118	411.252	411.594	410.963	411.232	0.025	0.060	-0.013	0.083	-0.982	-1.340	
1.917	0.997	0.997	0.965	421.674	411.079	411.181	411.499	410.903	411.166	0.025	0.057	-0.010	0.083	-2.375	-1.297	
1.958	0.996	0.997	0.965	421.633	411.033	411.198	411.513	410.891	411.159	0.025	0.059	-0.016	0.084	-0.881	-0.733	
2.000	0.996	0.996	0.965	421.555	411.003	411.113	411.466	410.885	411.117	0.025	0.056	-0.011	0.085	-0.766	-1.138	

Survey 4

Five-hole Probe Experiment - Reduced Data **Survey #4 04/05/00**

y/S	Cpt1	Cpt2	Cps1	P1	P2	P3	P4	P5	Pavg	Beta	Gamma	Delta	X	PHI	PSI
0.000	0.996	0.995	0.964	421.323	411.475	411.406	411.856	411.280	411.504	0.023	0.059	0.007	0.083	-0.326	-0.387
0.042	0.996	0.994	0.964	421.152	411.403	411.275	411.823	411.189	411.423	0.023	0.065	0.013	0.082	-0.470	-0.508
0.083	0.995	0.995	0.964	421.444	411.535	411.420	411.852	411.330	411.534	0.024	0.053	0.012	0.083	-0.174	-0.465
0.125	0.996	0.994	0.965	421.196	411.631	411.486	411.884	411.318	411.580	0.023	0.059	0.015	0.082	-0.328	-0.562
0.167	0.996	0.994	0.964	421.147	411.732	411.563	411.956	411.239	411.622	0.023	0.075	0.018	0.081	-0.707	-0.611
0.208	0.996	0.995	0.965	421.401	411.767	411.571	412.059	410.933	411.583	0.023	0.115	0.020	0.082	-1.526	-0.599
0.250	0.996	0.995	0.964	421.688	411.793	411.599	412.187	410.912	411.623	0.024	0.127	0.019	0.083	-1.734	-0.550
0.292	0.996	0.995	0.964	421.773	411.706	411.350	412.390	410.717	411.541	0.024	0.163	0.035	0.083	-2.371	-0.824
0.333	0.996	0.994	0.964	421.160	411.643	411.367	412.154	410.940	411.526	0.023	0.126	0.029	0.081	-1.760	-0.787
0.375	0.996	0.991	0.964	419.854	411.626	411.362	411.837	411.167	411.498	0.020	0.080	0.032	0.076	-0.856	-1.001
0.417	0.996	0.988	0.964	418.694	411.638	411.301	411.608	411.350	411.474	0.017	0.036	0.047	0.071	0.371	-1.301
0.458	0.996	0.986	0.964	418.100	411.657	411.381	411.537	411.361	411.484	0.016	0.027	0.042	0.068	0.724	-1.089
0.500	0.996	0.986	0.964	418.167	411.688	411.272	411.537	411.377	411.468	0.016	0.024	0.062	0.068	0.767	-1.554
0.542	0.996	0.989	0.963	419.226	411.711	411.201	411.546	411.458	411.479	0.018	0.011	0.066	0.074	0.979	-1.695
0.583	0.996	0.991	0.963	420.056	411.791	411.102	411.635	411.558	411.521	0.020	0.009	0.081	0.077	0.960	-1.922
0.625	0.996	0.992	0.964	420.557	411.872	411.030	411.853	411.560	411.579	0.021	0.033	0.094	0.079	0.355	-2.071
0.667	0.996	0.993	0.964	420.989	411.916	410.972	411.969	411.463	411.580	0.022	0.054	0.100	0.081	-0.127	-2.077
0.708	0.996	0.994	0.964	421.303	411.952	410.919	412.053	411.417	411.585	0.023	0.065	0.106	0.082	-0.362	-2.095
0.750	0.996	0.994	0.964	421.520	411.974	410.913	412.160	411.726	411.693	0.023	0.044	0.108	0.083	0.119	-2.094
0.792	0.996	0.995	0.963	421.633	411.984	411.108	412.294	410.985	411.592	0.024	0.130	0.087	0.083	-1.692	-1.777
0.833	0.996	0.995	0.964	421.717	411.979	411.295	412.266	410.807	411.587	0.024	0.144	0.068	0.083	-1.961	-1.434
0.875	0.996	0.995	0.964	421.860	411.970	411.100	412.418	410.649	411.534	0.024	0.171	0.084	0.083	-2.435	-1.762
0.917	0.996	0.995	0.964	421.914	411.959	411.119	412.432	410.785	411.574	0.025	0.159	0.081	0.084	-2.206	-1.670
0.958	0.996	0.996	0.964	422.024	411.998	411.187	412.353	411.081	411.655	0.025	0.123	0.078	0.084	-1.491	-1.536
1.000	0.996	0.995	0.964	421.709	412.027	411.034	412.299	411.129	411.622	0.024	0.116	0.098	0.083	-1.390	-1.928
1.042	0.996	0.995	0.963	421.681	412.071	410.915	412.260	411.435	411.670	0.024	0.082	0.115	0.083	-0.696	-2.168
1.083	0.996	0.995	0.964	421.577	412.057	411.249	412.293	411.349	411.737	0.023	0.096	0.082	0.082	-1.022	-1.694
1.125	0.996	0.995	0.963	421.951	412.049	410.813	412.375	411.206	411.611	0.025	0.113	0.119	0.084	-1.291	-2.197
1.167	0.996	0.996	0.964	421.976	412.054	410.863	412.425	410.837	411.545	0.025	0.152	0.114	0.084	-2.056	-2.211
1.208	0.996	0.996	0.964	421.970	412.056	410.928	412.411	410.896	411.573	0.025	0.146	0.108	0.084	-1.931	-2.098
1.250	0.996	0.995	0.964	421.977	411.999	411.076	412.376	411.392	411.711	0.024	0.096	0.090	0.084	-0.955	-1.717
1.292	0.996	0.995	0.963	421.700	411.918	411.234	412.314	411.135	411.650	0.024	0.117	0.068	0.083	-1.447	-1.426
1.333	0.996	0.993	0.963	421.012	411.766	411.324	412.101	411.451	411.661	0.022	0.070	0.047	0.081	-0.538	-1.189
1.375	0.996	0.991	0.964	419.961	411.698	411.384	411.825	411.533	411.610	0.020	0.035	0.038	0.076	0.296	-1.126
1.417	0.996	0.989	0.964	419.114	411.720	411.343	411.653	411.849	411.641	0.018	-0.026	0.050	0.072	2.109	-1.349
1.458	0.996	0.988	0.964	418.771	411.712	411.348	411.645	411.710	411.604	0.017	-0.009	0.051	0.071	1.666	-1.337
1.500	0.996	0.989	0.964	418.908	411.760	411.303	411.597	411.668	411.582	0.017	-0.010	0.062	0.072	1.642	-1.592
1.542	0.996	0.990	0.964	419.689	411.801	411.179	411.596	411.694	411.568	0.019	-0.012	0.077	0.075	1.571	-1.880
1.583	0.996	0.992	0.963	420.445	411.874	411.048	411.712	411.654	411.572	0.021	0.006	0.093	0.079	1.004	-2.091
1.625	0.996	0.994	0.964	421.098	411.942	410.924	411.873	411.757	411.624	0.022	0.012	0.108	0.081	0.848	-2.201
1.667	0.996	0.994	0.963	421.326	412.017	410.779	411.973	411.809	411.645	0.023	0.017	0.128	0.082	0.751	-2.460
1.708	0.996	0.995	0.964	421.606	412.040	410.661	412.044	411.476	411.555	0.024	0.057	0.137	0.083	-0.126	-2.470
1.750	0.996	0.995	0.964	421.738	412.031	410.708	412.186	411.190	411.529	0.024	0.098	0.130	0.084	-0.992	-2.355
1.792	0.996	0.995	0.964	421.618	411.993	410.781	412.256	411.091	411.530	0.024	0.116	0.120	0.083	-1.379	-2.280
1.833	0.996	0.996	0.963	422.046	412.010	410.814	412.407	410.831	411.515	0.025	0.150	0.114	0.085	-1.988	-2.167
1.875	0.996	0.996	0.963	422.110	412.011	410.850	412.483	410.586	411.483	0.025	0.179	0.109	0.085	-2.527	-2.196
1.917	0.996	0.996	0.963	422.148	412.020	411.082	412.502	410.492	411.524	0.025	0.189	0.088	0.085	-2.716	-1.845
1.958	0.996	0.996	0.963	422.178	412.084	410.759	412.475	410.726	411.511	0.025	0.164	0.124	0.085	-2.256	-2.387
2.000	0.996	0.996	0.964	422.151	412.076	410.823	412.397	410.836	411.533	0.025	0.147	0.118	0.085	-1.925	-2.214

Survey 5

Five-hole Probe Experiment - Reduced Data														Survey #5 04/11/00		
y/S	Cpt1	Cpt2	Cps1	P1	P2	P3	P4	P5	Pavg	Beta	Gamma	Delta	X	PHI	PSI	
0.000	0.996	0.992	0.963	420.502	411.665	410.700	411.914	410.688	411.242	0.022	0.132	0.104	0.079	-1.854	-2.270	
0.042	0.996	0.992	0.963	420.426	411.679	410.606	411.894	410.879	411.264	0.022	0.111	0.117	0.079	-1.415	-2.471	
0.083	0.996	0.993	0.963	420.811	411.660	410.634	411.885	410.895	411.269	0.023	0.104	0.107	0.081	-1.211	-2.194	
0.125	0.996	0.992	0.963	420.516	411.698	410.657	411.905	410.854	411.278	0.022	0.114	0.113	0.080	-1.468	-2.381	
0.167	0.996	0.993	0.963	420.882	411.721	410.596	412.039	410.624	411.245	0.023	0.147	0.117	0.081	-2.090	-2.435	
0.208	0.996	0.994	0.963	421.430	411.716	410.522	412.107	410.574	411.230	0.024	0.150	0.117	0.083	-2.060	-2.308	
0.250	0.996	0.994	0.963	421.319	411.640	410.649	412.132	410.447	411.217	0.024	0.167	0.098	0.083	-2.389	-2.052	
0.292	0.996	0.994	0.962	421.385	411.504	410.889	412.134	410.413	411.235	0.024	0.170	0.061	0.083	-2.451	-1.340	
0.333	0.996	0.992	0.963	420.630	411.299	411.202	411.807	411.098	411.351	0.022	0.076	0.010	0.080	-0.762	-0.495	
0.375	0.996	0.990	0.963	419.728	411.133	411.205	411.473	411.072	411.221	0.020	0.047	-0.008	0.077	-0.061	-0.144	
0.417	0.996	0.987	0.962	418.507	411.082	411.240	411.273	411.155	411.188	0.017	0.016	-0.022	0.071	0.949	0.252	
0.458	0.996	0.984	0.962	417.371	411.117	411.189	411.193	411.195	411.174	0.015	0.000	-0.012	0.065	1.666	0.273	
0.500	0.996	0.984	0.962	417.040	411.259	411.135	411.178	411.213	411.196	0.014	-0.006	0.021	0.063	1.899	-0.354	
0.542	0.996	0.986	0.963	417.850	411.385	411.020	411.301	411.155	411.215	0.016	0.022	0.055	0.068	0.843	-1.385	
0.583	0.996	0.989	0.962	419.247	411.462	410.857	411.472	411.031	411.206	0.019	0.055	0.075	0.075	-0.198	-1.892	
0.625	0.996	0.991	0.962	419.992	411.585	410.711	411.684	411.026	411.252	0.021	0.075	0.100	0.078	-0.666	-2.234	
0.667	0.996	0.991	0.962	420.252	411.686	410.567	411.766	410.953	411.243	0.021	0.090	0.124	0.079	-0.979	-2.589	
0.708	0.996	0.992	0.962	420.531	411.734	410.535	411.830	410.955	411.263	0.022	0.094	0.129	0.080	-1.044	-2.609	
0.750	0.996	0.992	0.962	420.637	411.760	410.470	411.920	410.742	411.223	0.022	0.125	0.137	0.080	-1.692	-2.775	
0.792	0.996	0.992	0.962	420.777	411.789	410.368	412.013	410.802	411.243	0.023	0.127	0.149	0.081	-1.729	-2.949	
0.833	0.996	0.994	0.963	421.237	411.814	410.365	412.067	410.622	411.217	0.024	0.144	0.145	0.083	-2.002	-2.808	
0.875	0.996	0.994	0.963	421.438	411.840	410.311	412.116	410.499	411.191	0.024	0.158	0.149	0.083	-2.250	-2.899	
0.917	0.996	0.995	0.962	421.648	411.886	410.345	412.135	410.424	411.198	0.025	0.164	0.147	0.084	-2.331	-2.850	
0.958	0.996	0.994	0.962	421.237	411.864	410.405	412.046	410.690	411.251	0.024	0.136	0.146	0.082	-1.836	-2.804	
1.000	0.996	0.994	0.962	421.441	411.922	410.301	411.937	410.953	411.278	0.024	0.097	0.160	0.083	-1.003	-2.829	
1.042	0.996	0.994	0.963	421.166	411.936	410.267	411.944	410.897	411.261	0.024	0.106	0.169	0.082	-1.244	-3.073	
1.083	0.996	0.993	0.962	421.133	411.946	410.258	411.969	410.925	411.274	0.023	0.106	0.171	0.082	-1.257	-3.131	
1.125	0.996	0.994	0.963	421.426	411.946	410.121	412.057	410.798	411.230	0.024	0.124	0.179	0.083	-1.611	-3.233	
1.167	0.996	0.995	0.963	421.626	411.949	410.211	412.110	410.773	411.261	0.025	0.129	0.168	0.084	-1.678	-3.027	
1.208	0.996	0.995	0.962	421.837	411.874	410.359	412.098	410.823	411.289	0.025	0.121	0.144	0.085	-1.437	-2.549	
1.250	0.996	0.994	0.962	421.621	411.825	410.509	412.043	410.974	411.338	0.024	0.104	0.128	0.084	-1.114	-2.323	
1.292	0.996	0.994	0.962	421.236	411.640	410.849	411.949	411.272	411.427	0.023	0.069	0.081	0.082	-0.450	-1.665	
1.333	0.996	0.993	0.963	420.808	411.349	411.151	411.651	411.304	411.364	0.022	0.037	0.021	0.081	0.206	-0.703	
1.375	0.996	0.991	0.963	419.954	411.198	411.258	411.454	411.499	411.352	0.020	-0.005	-0.007	0.078	1.381	-0.191	
1.417	0.996	0.988	0.962	418.954	411.199	411.233	411.276	411.318	411.256	0.018	-0.005	-0.004	0.073	1.517	-0.205	
1.458	0.996	0.986	0.962	418.133	411.266	411.206	411.253	411.301	411.257	0.016	-0.007	0.009	0.069	1.704	-0.381	
1.500	0.996	0.986	0.962	417.954	411.352	411.167	411.275	411.314	411.277	0.016	-0.006	0.028	0.068	1.698	-0.759	
1.542	0.996	0.988	0.962	418.837	411.498	411.129	411.381	411.363	411.343	0.018	0.002	0.049	0.072	1.278	-1.349	
1.583	0.996	0.991	0.963	419.905	411.613	411.069	411.525	411.406	411.403	0.020	0.014	0.064	0.077	0.833	-1.623	
1.625	0.996	0.993	0.962	420.834	411.677	410.915	411.724	411.151	411.367	0.022	0.061	0.080	0.081	-0.291	-1.740	
1.667	0.996	0.993	0.962	421.080	411.746	410.531	411.593	410.914	411.196	0.023	0.069	0.123	0.083	-0.411	-2.304	
1.708	0.996	0.993	0.962	421.112	411.796	410.717	411.889	411.214	411.404	0.023	0.070	0.111	0.082	-0.452	-2.173	
1.750	0.996	0.993	0.962	420.949	411.795	410.456	411.917	411.201	411.342	0.023	0.074	0.139	0.081	-0.564	-2.638	
1.792	0.996	0.994	0.962	421.332	411.881	410.317	412.018	410.843	411.265	0.024	0.117	0.155	0.083	-1.438	-2.854	
1.833	0.996	0.993	0.962	421.426	411.868	410.270	412.133	411.434	411.427	0.024	0.070	0.160	0.083	-0.430	-2.831	
1.875	0.996	0.995	0.962	421.930	411.895	410.253	412.214	410.701	411.266	0.025	0.142	0.154	0.085	-1.869	-2.784	
1.917	0.996	0.995	0.962	421.980	411.880	410.344	412.227	410.731	411.295	0.025	0.140	0.144	0.085	-1.810	-2.599	
1.958	0.996	0.995	0.962	421.913	411.901	410.311	412.185	410.731	411.282	0.025	0.137	0.150	0.085	-1.762	-2.694	
2.000	0.996	0.995	0.962	421.944	411.941	410.280	412.129	410.934	411.321	0.025	0.112	0.156	0.085	-1.274	-2.702	

Survey 6

Five-hole Probe Experiment - Reduced Data — Survey #6 04/12/00

y/S	Cpt1	Cpt2	Cps1	P1	P2	P3	P4	P5	Pavg	Beta	Gamma	Delta	X	PHI	PSI
0.000	0.996	0.991	0.963	419.902	411.962	410.318	411.891	411.465	411.409	0.020	0.050	0.194	0.076	-0.074	-3.764
0.042	0.996	0.990	0.963	419.624	411.996	410.083	411.899	411.225	411.301	0.020	0.081	0.230	0.075	-0.919	-4.483
0.083	0.996	0.991	0.964	419.836	412.115	409.943	411.829	411.347	411.309	0.020	0.056	0.255	0.076	-0.268	-4.771
0.125	0.996	0.991	0.964	420.030	412.211	409.966	411.871	411.217	411.316	0.021	0.075	0.258	0.077	-0.764	-4.809
0.167	0.996	0.993	0.964	420.372	412.252	409.812	411.937	411.407	411.352	0.021	0.059	0.271	0.078	-0.316	-4.913
0.208	0.996	0.993	0.963	420.552	412.239	409.900	411.955	411.237	411.333	0.022	0.078	0.254	0.079	-0.795	-4.593
0.250	0.996	0.992	0.964	420.341	412.045	410.135	411.918	411.381	411.370	0.021	0.060	0.213	0.078	-0.303	-3.939
0.292	0.996	0.990	0.963	419.522	411.717	410.932	411.808	411.327	411.446	0.019	0.060	0.097	0.075	-0.316	-2.297
0.333	0.996	0.987	0.963	418.288	411.355	411.238	411.546	411.487	411.407	0.016	0.009	0.017	0.069	1.230	-0.571
0.375	0.996	0.985	0.963	417.487	411.119	411.325	411.374	411.473	411.323	0.015	-0.016	-0.034	0.065	2.170	0.770
0.417	0.996	0.983	0.963	416.477	411.049	411.196	411.201	411.339	411.196	0.013	-0.026	-0.028	0.060	2.665	0.945
0.458	0.996	0.982	0.964	416.039	411.134	411.180	411.173	411.304	411.198	0.012	-0.027	-0.009	0.057	2.795	0.779
0.500	0.996	0.983	0.964	416.403	411.319	411.088	411.275	411.317	411.250	0.012	-0.008	0.045	0.059	2.104	-0.569
0.542	0.996	0.985	0.964	417.017	411.511	411.091	411.352	411.328	411.321	0.014	0.004	0.074	0.062	1.533	-1.512
0.583	0.996	0.987	0.964	418.094	411.703	410.851	411.554	411.402	411.378	0.016	0.023	0.127	0.068	0.722	-2.897
0.625	0.996	0.989	0.963	418.935	411.767	410.417	411.748	411.133	411.266	0.018	0.080	0.176	0.073	-0.908	-3.799
0.667	0.996	0.990	0.963	419.317	411.826	410.333	411.810	411.056	411.256	0.019	0.094	0.185	0.074	-1.213	-3.880
0.708	0.996	0.991	0.963	419.689	411.904	410.141	411.774	411.192	411.253	0.020	0.069	0.209	0.076	-0.572	-4.061
0.750	0.996	0.991	0.964	419.731	411.976	410.108	411.825	411.093	411.250	0.020	0.086	0.220	0.076	-1.027	-4.288
0.792	0.996	0.991	0.963	419.979	412.056	409.909	411.873	411.626	411.366	0.021	0.029	0.249	0.077	0.503	-4.628
0.833	0.996	0.992	0.964	420.151	412.120	409.778	411.927	411.521	411.336	0.021	0.046	0.266	0.077	0.030	-4.866
0.875	0.996	0.993	0.964	420.513	412.117	409.845	411.908	410.844	411.178	0.022	0.114	0.243	0.080	-1.677	-4.538
0.917	0.996	0.993	0.964	420.353	412.153	409.850	411.996	411.434	411.358	0.021	0.062	0.256	0.078	-0.404	-4.661
0.958	0.996	0.993	0.964	420.461	412.138	409.903	411.867	411.243	411.288	0.022	0.068	0.244	0.079	-0.526	-4.402
1.000	0.996	0.992	0.964	420.284	412.196	409.900	411.916	411.411	411.356	0.021	0.057	0.257	0.078	-0.248	-4.691
1.042	0.997	0.993	0.964	420.313	412.193	409.812	411.872	411.247	411.281	0.021	0.069	0.264	0.078	-0.589	-4.800
1.083	0.996	0.993	0.964	420.434	412.301	409.589	411.897	411.427	411.303	0.022	0.052	0.297	0.079	-0.134	-5.400
1.125	0.996	0.994	0.964	420.700	412.346	409.694	411.911	411.378	411.332	0.022	0.057	0.283	0.080	-0.264	-5.062
1.167	0.996	0.994	0.964	420.697	412.331	409.708	411.903	411.438	411.345	0.022	0.050	0.280	0.080	-0.060	-5.006
1.208	0.996	0.994	0.964	420.625	412.216	409.934	411.809	411.342	411.325	0.022	0.050	0.245	0.080	-0.052	-4.372
1.250	0.996	0.992	0.964	420.155	411.986	410.337	411.707	411.537	411.392	0.021	0.019	0.188	0.078	0.730	-3.602
1.292	0.996	0.990	0.964	419.338	411.620	410.773	411.582	411.625	411.400	0.019	-0.005	0.107	0.074	1.401	-2.437
1.333	0.996	0.988	0.964	418.441	411.335	411.000	411.489	411.538	411.341	0.017	-0.007	0.047	0.070	1.621	-1.257
1.375	0.996	0.986	0.964	417.686	411.144	411.127	411.295	411.368	411.233	0.015	-0.011	0.003	0.067	1.935	-0.140
1.417	0.996	0.985	0.964	417.027	411.115	411.169	411.268	411.363	411.229	0.014	-0.016	-0.009	0.063	2.251	0.348
1.458	0.996	0.983	0.963	416.502	411.208	411.116	411.243	411.351	411.229	0.013	-0.021	0.017	0.060	2.492	-0.017
1.500	0.996	0.984	0.963	416.916	411.415	410.989	411.304	411.345	411.263	0.014	-0.007	0.075	0.062	1.896	-1.508
1.542	0.996	0.986	0.963	417.696	411.591	410.715	411.429	411.399	411.284	0.015	0.005	0.137	0.066	1.266	-3.041
1.583	0.996	0.988	0.963	418.656	411.711	410.491	411.611	411.438	411.313	0.018	0.024	0.166	0.071	0.622	-3.566
1.625	0.996	0.990	0.963	419.505	411.797	410.303	411.772	411.121	411.248	0.020	0.079	0.181	0.075	-0.819	-3.699
1.667	0.996	0.991	0.963	419.876	411.856	410.224	411.800	411.011	411.223	0.021	0.091	0.189	0.077	-1.089	-3.733
1.708	0.996	0.991	0.963	419.757	411.878	410.170	411.823	411.205	411.269	0.020	0.073	0.201	0.076	-0.659	-3.931
1.750	0.996	0.992	0.964	419.904	411.934	410.057	411.812	411.279	411.270	0.021	0.062	0.217	0.077	-0.377	-4.117
1.792	0.996	0.992	0.963	420.106	412.020	409.924	411.876	411.118	411.234	0.021	0.085	0.236	0.078	-0.988	-4.420
1.833	0.996	0.993	0.963	420.451	412.027	409.889	411.958	410.881	411.189	0.022	0.116	0.231	0.080	-1.705	-4.354
1.875	0.996	0.993	0.964	420.712	412.069	409.805	412.013	410.896	411.196	0.023	0.117	0.238	0.081	-1.722	-4.407
1.917	0.996	0.994	0.963	420.890	412.052	409.776	411.997	410.849	411.169	0.023	0.118	0.234	0.081	-1.705	-4.282
1.958	0.996	0.994	0.964	420.732	412.048	409.835	411.971	410.938	411.198	0.023	0.108	0.232	0.081	-1.484	-4.247
2.000	0.996	0.993	0.963	420.757	412.036	409.888	411.940	410.929	411.198	0.023	0.106	0.225	0.081	-1.401	-4.099

Survey 7

Five-hole Probe Experiment - Reduced Data **Survey #7 04/26/00**

y/S	Cpt1	Cpt2	Cps1	P1	P2	P3	P4	P5	Pavg	Beta	Gamma	Delta	X	PHI	PSI
0.000	0.996	0.988	0.964	418.830	412.476	409.680	411.700	411.013	411.217	0.018	0.090	0.367	0.072	-1.396	-7.633
0.042	0.996	0.989	0.964	418.971	412.471	409.791	411.715	410.756	411.183	0.019	0.123	0.344	0.073	-2.351	-7.160
0.083	0.996	0.989	0.964	419.054	412.494	409.655	411.751	411.603	411.376	0.018	0.019	0.370	0.072	0.799	-7.589
0.125	0.996	0.990	0.964	419.264	412.377	409.829	411.886	411.382	411.368	0.019	0.064	0.323	0.073	-0.562	-6.370
0.167	0.996	0.990	0.965	419.506	412.363	409.787	411.932	411.005	411.272	0.020	0.113	0.313	0.075	-1.945	-6.241
0.208	0.996	0.991	0.964	419.881	412.215	410.098	412.022	410.977	411.328	0.020	0.122	0.248	0.077	-1.989	-4.926
0.250	0.996	0.991	0.964	419.624	412.046	410.314	412.067	410.961	411.347	0.020	0.134	0.209	0.075	-2.208	-4.425
0.292	0.996	0.990	0.964	419.472	411.849	410.627	412.077	410.993	411.387	0.019	0.134	0.151	0.074	-2.129	-3.455
0.333	0.996	0.989	0.965	419.026	411.645	410.867	411.969	411.155	411.409	0.018	0.107	0.102	0.072	-1.513	-2.549
0.375	0.996	0.987	0.964	418.150	411.523	411.003	411.800	411.238	411.391	0.016	0.083	0.077	0.068	-0.933	-2.015
0.417	0.996	0.985	0.964	417.356	411.452	411.074	411.496	411.472	411.374	0.014	0.004	0.063	0.064	1.499	-1.369
0.458	0.996	0.984	0.964	416.894	411.513	411.116	411.238	411.438	411.326	0.013	-0.036	0.071	0.061	2.816	-1.332
0.500	0.996	0.983	0.965	416.180	411.677	410.978	410.939	411.551	411.286	0.012	-0.125	0.143	0.057	5.357	-2.591
0.542	0.996	0.982	0.964	416.036	411.937	410.736	410.805	411.461	411.235	0.012	-0.137	0.250	0.057	5.406	-4.921
0.583	0.996	0.983	0.964	416.291	412.151	410.491	410.776	411.377	411.199	0.012	-0.118	0.326	0.059	4.750	-6.851
0.625	0.996	0.984	0.964	416.658	412.342	410.134	410.866	411.144	411.121	0.013	-0.050	0.399	0.061	2.812	-8.880
0.667	0.996	0.985	0.964	417.176	412.487	409.915	410.999	410.944	411.086	0.015	0.009	0.422	0.064	1.139	-9.496
0.708	0.996	0.986	0.964	417.442	412.606	409.765	411.154	410.843	411.092	0.015	0.049	0.447	0.066	0.006	-10.170
0.750	0.996	0.987	0.964	418.006	412.646	409.552	411.314	410.835	411.087	0.017	0.069	0.447	0.068	-0.653	-10.084
0.792	0.996	0.988	0.964	418.314	412.692	409.447	411.443	411.081	411.166	0.017	0.051	0.454	0.070	-0.064	-10.234
0.833	0.996	0.988	0.964	418.748	412.699	409.395	411.523	411.185	411.201	0.018	0.045	0.438	0.072	0.072	-9.643
0.875	0.996	0.989	0.964	418.858	412.704	409.388	411.593	411.077	411.191	0.018	0.067	0.433	0.072	-0.656	-9.458
0.917	0.996	0.990	0.964	419.114	412.669	409.362	411.659	411.241	411.233	0.019	0.053	0.420	0.073	-0.224	-8.984
0.958	0.996	0.990	0.964	419.258	412.663	409.449	411.674	411.111	411.225	0.019	0.070	0.400	0.074	-0.774	-8.355
1.000	0.996	0.990	0.964	419.333	412.649	409.455	411.745	411.366	411.304	0.019	0.047	0.398	0.074	-0.054	-8.271
1.042	0.996	0.991	0.964	419.573	412.644	409.466	411.757	411.224	411.273	0.020	0.064	0.383	0.075	-0.590	-7.766
1.083	0.996	0.991	0.964	419.840	412.617	409.479	411.806	411.669	411.393	0.020	0.016	0.371	0.076	0.905	-7.420
1.125	0.996	0.992	0.964	420.178	412.553	409.504	411.897	411.662	411.404	0.021	0.027	0.348	0.077	0.576	-6.676
1.167	0.996	0.992	0.964	420.327	412.463	409.659	411.990	411.136	411.312	0.021	0.095	0.311	0.078	-1.387	-5.852
1.208	0.996	0.992	0.964	420.215	412.285	409.973	412.016	410.842	411.279	0.021	0.131	0.259	0.078	-2.205	-5.067
1.250	0.996	0.991	0.964	419.879	412.105	410.345	412.000	411.097	411.387	0.020	0.106	0.207	0.076	-1.507	-4.156
1.292	0.996	0.989	0.964	419.053	411.968	410.607	411.833	411.366	411.443	0.018	0.061	0.179	0.072	-0.416	-3.810
1.333	0.996	0.987	0.964	417.921	411.822	410.804	411.297	411.158	411.270	0.016	0.021	0.153	0.068	0.736	-3.415
1.375	0.996	0.984	0.964	416.819	411.839	411.140	411.364	411.681	411.506	0.013	-0.060	0.132	0.060	3.443	-2.578
1.417	0.996	0.983	0.964	416.274	411.936	411.154	411.118	411.528	411.434	0.012	-0.085	0.162	0.057	4.158	-3.149
1.458	0.996	0.982	0.964	416.031	412.027	410.711	410.899	411.501	411.285	0.011	-0.127	0.277	0.057	5.092	-5.582
1.500	0.996	0.982	0.963	416.130	412.229	410.463	410.800	411.406	411.224	0.012	-0.124	0.360	0.058	4.965	-7.441
1.542	0.996	0.983	0.964	416.506	412.362	410.166	410.648	410.827	411.001	0.013	-0.033	0.399	0.061	2.267	-8.976
1.583	0.996	0.984	0.964	416.853	412.503	409.946	410.617	410.887	410.988	0.014	-0.046	0.436	0.064	2.848	-9.699
1.625	0.996	0.985	0.964	417.234	412.565	409.837	411.126	410.882	411.103	0.015	0.040	0.445	0.064	0.281	-10.122
1.667	0.996	0.986	0.964	417.711	412.661	409.667	411.279	410.935	411.135	0.016	0.052	0.455	0.067	-0.081	-10.356
1.708	0.996	0.987	0.964	418.110	412.697	409.615	411.405	411.087	411.201	0.017	0.046	0.446	0.069	0.081	-10.026
1.750	0.996	0.988	0.964	418.425	412.681	409.585	411.514	411.111	411.223	0.017	0.056	0.430	0.070	-0.278	-9.479
1.792	0.996	0.989	0.964	418.806	412.689	409.571	411.594	411.085	411.235	0.018	0.067	0.412	0.072	-0.670	-8.841
1.833	0.996	0.989	0.964	419.115	412.707	409.526	411.690	411.141	411.266	0.019	0.070	0.405	0.073	-0.766	-8.561
1.875	0.996	0.990	0.964	419.407	412.664	409.608	411.745	411.309	411.331	0.019	0.054	0.378	0.074	-0.269	-7.698
1.917	0.996	0.990	0.964	419.557	412.635	409.627	411.839	411.310	411.352	0.020	0.065	0.367	0.075	-0.592	-7.344
1.958	0.996	0.991	0.964	419.510	412.567	409.730	411.849	411.488	411.408	0.019	0.045	0.350	0.074	0.024	-6.925
2.000	0.996	0.991	0.964	419.612	412.496	409.855	411.924	411.425	411.425	0.020	0.061	0.323	0.074	-0.461	-6.255

Survey 8

Five-hole Probe Experiment - Reduced Data — **Survey #8 05/17/00**

y/S	Cpt1	Cpt2	Cps1	P1	P2	P3	P4	P5	Pavg	Beta	Gamma	Delta	X	PHI	PSI
0.000	0.997	0.988	0.963	418.963	413.566	408.699	411.016	410.604	410.971	0.019	0.052	0.609	0.074	-0.190	-14.882
0.042	0.996	0.989	0.963	419.129	413.526	408.836	411.048	410.740	411.037	0.019	0.038	0.580	0.075	0.261	-14.239
0.083	0.996	0.989	0.963	419.181	413.411	408.840	411.148	410.844	411.061	0.019	0.038	0.563	0.075	0.278	-13.805
0.125	0.996	0.988	0.962	419.061	413.138	409.144	411.332	411.285	411.225	0.019	0.006	0.510	0.074	1.316	-12.026
0.167	0.996	0.987	0.963	418.388	412.770	409.551	410.947	410.976	411.061	0.018	-0.004	0.439	0.071	1.605	-9.745
0.208	0.996	0.984	0.963	417.019	412.428	410.019	410.916	411.021	411.096	0.014	-0.018	0.407	0.064	1.884	-9.108
0.250	0.996	0.981	0.963	415.724	412.363	410.351	411.158	411.257	411.282	0.011	-0.022	0.453	0.054	2.102	-9.753
0.292	0.996	0.979	0.963	414.984	412.622	410.307	410.835	410.947	411.178	0.009	-0.029	0.608	0.050	2.530	-14.045
0.333	0.995	0.979	0.963	415.197	412.986	410.035	410.600	410.734	411.089	0.010	-0.033	0.718	0.040	0.000	0.000
0.375	0.996	0.980	0.963	415.405	413.394	409.681	410.170	410.239	410.871	0.011	-0.015	0.819	0.040	0.000	0.000
0.417	0.996	0.981	0.963	415.789	413.476	409.495	410.117	410.171	410.815	0.012	-0.011	0.800	0.040	0.000	0.000
0.458	0.996	0.981	0.963	416.006	413.581	409.293	410.061	410.063	410.749	0.013	0.000	0.816	0.040	0.000	0.000
0.500	0.996	0.982	0.963	416.199	413.681	409.167	409.946	409.940	410.683	0.013	0.001	0.819	0.040	0.000	0.000
0.542	0.996	0.982	0.963	416.365	413.754	409.104	409.910	409.886	410.663	0.014	0.004	0.816	0.040	0.000	0.000
0.583	0.996	0.983	0.963	416.577	413.802	408.975	409.905	409.920	410.650	0.014	-0.003	0.815	0.040	0.000	0.000
0.625	0.996	0.984	0.963	417.036	413.850	409.050	409.987	409.943	410.708	0.015	0.007	0.758	0.040	0.000	0.000
0.667	0.995	0.984	0.963	417.324	413.895	408.954	410.083	410.014	410.736	0.016	0.010	0.750	0.059	-1.711	-13.827
0.708	0.996	0.985	0.963	417.622	413.869	408.942	410.150	410.133	410.773	0.016	0.002	0.719	0.063	0.105	-13.401
0.750	0.996	0.986	0.963	417.827	413.825	408.871	410.243	410.235	410.794	0.017	0.001	0.704	0.065	0.627	-13.329
0.792	0.996	0.987	0.963	418.164	413.832	408.815	410.657	410.686	410.998	0.017	-0.004	0.700	0.066	0.948	-13.048
0.833	0.996	0.987	0.963	418.429	413.805	408.877	410.823	410.683	411.047	0.018	0.019	0.668	0.069	0.610	-14.325
0.875	0.996	0.988	0.963	418.689	413.716	408.830	410.953	410.920	411.105	0.018	0.004	0.644	0.071	1.220	-14.313
0.917	0.996	0.989	0.963	419.015	413.675	408.843	410.948	410.895	411.090	0.019	0.007	0.610	0.074	1.201	-14.380
0.958	0.996	0.989	0.963	419.054	413.609	408.801	411.075	411.089	411.143	0.019	-0.002	0.608	0.074	1.448	-14.243
1.000	0.996	0.989	0.963	419.294	413.527	408.860	411.025	411.008	411.105	0.020	0.002	0.570	0.076	1.330	-13.743
1.042	0.996	0.990	0.963	419.511	413.483	408.792	411.207	411.234	411.179	0.020	-0.003	0.563	0.077	1.458	-13.541
1.083	0.996	0.990	0.963	419.672	413.344	408.934	411.197	411.172	411.162	0.020	0.003	0.518	0.077	1.283	-12.287
1.125	0.996	0.990	0.963	419.589	413.161	409.058	411.394	411.414	411.257	0.020	-0.002	0.492	0.076	1.495	-11.419
1.167	0.996	0.988	0.963	419.022	412.770	409.557	411.443	411.359	411.282	0.018	0.011	0.415	0.073	1.107	-8.902
1.208	0.996	0.985	0.962	417.535	412.450	409.996	410.976	411.135	411.139	0.015	-0.025	0.384	0.066	2.084	-8.413
1.250	0.996	0.981	0.963	415.811	412.413	410.362	411.137	411.333	411.311	0.011	-0.044	0.456	0.055	2.823	-9.585
1.292	0.996	0.979	0.962	415.277	412.598	410.390	410.836	411.046	411.217	0.010	-0.052	0.544	0.052	3.625	-10.487
1.333	0.996	0.979	0.963	415.330	413.004	409.984	410.223	410.405	410.904	0.011	-0.041	0.682	0.040	0.000	0.000
1.375	0.996	0.980	0.963	415.556	413.300	409.706	410.290	410.363	410.915	0.011	-0.016	0.775	0.040	0.000	0.000
1.417	0.996	0.981	0.963	416.000	413.446	409.408	410.132	410.171	410.789	0.013	-0.007	0.775	0.040	0.000	0.000
1.458	0.996	0.982	0.963	416.118	413.612	409.271	410.020	409.989	410.723	0.013	0.006	0.805	0.040	0.000	0.000
1.500	0.996	0.982	0.963	416.470	413.672	409.243	409.943	409.902	410.690	0.014	0.007	0.766	0.040	0.000	0.000
1.542	0.996	0.983	0.963	416.523	413.704	409.153	409.992	409.932	410.695	0.014	0.010	0.781	0.040	0.000	0.000
1.583	0.995	0.983	0.963	416.914	413.753	409.166	409.986	409.978	410.721	0.015	0.001	0.741	0.040	0.000	0.000
1.625	0.996	0.984	0.963	417.143	413.743	409.069	410.043	410.027	410.721	0.015	0.002	0.728	0.040	0.000	0.000
1.667	0.996	0.985	0.963	417.373	413.821	409.116	410.152	410.111	410.800	0.016	0.006	0.716	0.063	-0.266	-14.828
1.708	0.996	0.986	0.963	417.739	413.809	408.980	410.184	410.547	410.880	0.016	-0.053	0.704	0.065	2.395	-13.311
1.750	0.996	0.986	0.963	417.941	413.767	409.093	410.298	410.276	410.859	0.017	0.003	0.660	0.068	1.147	-14.415
1.792	0.996	0.987	0.963	418.255	413.758	408.962	410.803	410.767	411.073	0.017	0.005	0.668	0.068	1.028	-14.229
1.833	0.996	0.988	0.963	418.602	413.694	409.041	410.691	410.825	411.063	0.018	-0.018	0.617	0.072	1.962	-14.064
1.875	0.997	0.988	0.963	418.731	413.655	408.958	410.849	411.077	411.135	0.018	-0.030	0.618	0.072	2.277	-13.859
1.917	0.996	0.988	0.963	418.976	413.555	409.010	411.039	410.995	411.150	0.019	0.006	0.581	0.074	1.295	-13.976
1.958	0.997	0.989	0.963	419.229	413.586	408.933	411.129	411.183	411.207	0.019	-0.007	0.580	0.075	1.607	-13.846
2.000	0.996	0.989	0.963	419.441	413.485	409.066	411.049	411.172	411.193	0.020	-0.015	0.536	0.076	1.845	-12.749

Survey 9

Five-hole Probe Experiment - Reduced Data — **Survey #9 05/18/00**

y/S	Cpt1	Cpt2	Cps1	P1	P2	P3	P4	P5	Pavg	Beta	Gamma	Delta	X	PHI	PSI
0.000	0.996	0.987	0.964	418.081	413.735	408.959	410.780	410.767	411.060	0.017	0.002	0.680	0.067	0.949	-14.148
0.042	0.996	0.987	0.964	418.121	413.611	409.012	410.888	410.843	411.088	0.017	0.006	0.654	0.068	1.088	-14.563
0.083	0.996	0.987	0.964	418.251	413.424	409.085	410.989	410.977	411.119	0.017	0.002	0.608	0.070	1.500	-14.297
0.125	0.996	0.986	0.964	417.991	413.173	409.283	411.152	411.141	411.187	0.016	0.002	0.572	0.069	1.652	-13.543
0.167	0.996	0.985	0.964	417.421	412.639	409.737	411.303	411.325	411.251	0.015	-0.004	0.470	0.065	1.714	-10.637
0.208	0.996	0.983	0.964	416.554	412.338	410.106	411.199	411.417	411.265	0.013	-0.041	0.422	0.060	2.606	-9.384
0.250	0.996	0.980	0.964	415.351	412.186	410.500	410.888	410.998	411.143	0.010	-0.026	0.401	0.053	1.863	-9.322
0.292	0.996	0.979	0.964	414.613	412.447	410.491	410.910	410.958	411.202	0.008	-0.014	0.573	0.046	2.316	-10.191
0.333	0.996	0.978	0.964	414.489	412.985	410.016	410.572	410.832	411.101	0.008	-0.077	0.877	0.040	0.000	0.000
0.375	0.996	0.979	0.964	414.754	413.342	409.811	410.283	410.309	410.936	0.009	-0.007	0.925	0.040	0.000	0.000
0.417	0.996	0.979	0.964	414.965	413.907	409.466	409.986	410.038	410.849	0.010	-0.013	1.079	0.040	0.000	0.000
0.458	0.996	0.980	0.964	415.203	413.835	409.305	409.796	409.815	410.688	0.011	-0.004	1.003	0.040	0.000	0.000
0.500	0.996	0.981	0.964	415.381	414.251	409.105	409.818	409.805	410.745	0.011	0.003	1.110	0.040	0.000	0.000
0.542	0.996	0.981	0.964	415.770	414.081	409.119	409.738	409.701	410.660	0.012	0.007	0.971	0.040	0.000	0.000
0.583	0.996	0.982	0.964	415.871	414.127	409.029	409.672	409.641	410.617	0.013	0.006	0.970	0.040	0.000	0.000
0.625	0.996	0.982	0.964	416.182	414.201	408.997	409.668	409.638	410.626	0.013	0.005	0.937	0.040	0.000	0.000
0.667	0.996	0.984	0.964	416.473	414.183	408.952	409.688	409.676	410.625	0.014	0.002	0.894	0.040	0.000	0.000
0.708	0.996	0.984	0.964	416.706	414.146	408.962	409.749	409.770	410.656	0.015	-0.003	0.857	0.040	0.000	0.000
0.750	0.996	0.985	0.964	416.979	414.132	408.963	409.866	409.897	410.714	0.015	-0.005	0.825	0.040	0.000	0.000
0.792	0.996	0.985	0.964	417.298	414.059	408.993	410.022	410.042	410.779	0.016	-0.003	0.777	0.055	-2.571	-13.442
0.833	0.997	0.986	0.964	417.503	413.988	409.008	410.090	410.135	410.805	0.016	-0.007	0.743	0.060	-0.420	-13.128
0.875	0.996	0.986	0.964	417.716	413.938	409.045	410.234	410.255	410.868	0.016	-0.003	0.715	0.064	0.432	-13.517
0.917	0.996	0.987	0.964	417.963	413.883	409.076	410.309	410.473	410.935	0.017	-0.023	0.684	0.067	1.743	-13.612
0.958	0.996	0.987	0.964	418.120	413.851	409.069	410.784	410.760	411.116	0.017	0.003	0.683	0.067	0.856	-14.150
1.000	0.996	0.988	0.964	418.275	413.716	409.188	410.477	410.505	410.972	0.017	-0.004	0.620	0.071	1.598	-14.319
1.042	0.996	0.988	0.965	418.258	413.650	409.249	410.952	410.959	411.202	0.017	-0.001	0.624	0.070	1.534	-14.422
1.083	0.996	0.988	0.964	418.499	413.550	409.333	411.077	411.052	411.253	0.017	0.003	0.582	0.071	1.486	-13.901
1.125	0.996	0.988	0.964	418.528	413.252	409.400	411.221	411.196	411.267	0.017	0.003	0.531	0.071	1.504	-12.600
1.167	0.996	0.987	0.964	417.967	412.773	409.853	410.978	411.004	411.152	0.016	-0.004	0.428	0.068	1.582	-9.498
1.208	0.996	0.985	0.964	416.925	412.400	410.279	411.057	411.095	411.208	0.014	-0.007	0.371	0.062	1.412	-8.429
1.250	0.997	0.981	0.964	415.486	412.220	410.677	411.241	411.369	411.377	0.010	-0.031	0.375	0.052	1.917	-9.021
1.292	0.996	0.979	0.964	414.675	412.488	410.521	410.881	411.224	411.278	0.008	-0.101	0.579	0.047	4.615	-12.672
1.333	0.996	0.979	0.963	414.638	413.038	410.153	410.499	410.761	411.113	0.009	-0.075	0.818	0.040	0.000	0.000
1.375	0.995	0.980	0.964	414.928	413.371	409.752	410.198	410.388	410.927	0.010	-0.048	0.905	0.040	0.000	0.000
1.417	0.996	0.980	0.964	415.110	413.934	409.475	409.999	410.125	410.883	0.010	-0.030	1.055	0.040	0.000	0.000
1.458	0.996	0.980	0.964	415.246	413.898	409.243	409.852	409.897	410.722	0.011	-0.010	1.029	0.040	0.000	0.000
1.500	0.996	0.981	0.964	415.460	413.980	409.159	409.839	409.809	410.697	0.011	0.006	1.012	0.040	0.000	0.000
1.542	0.996	0.982	0.964	415.741	414.014	409.231	409.812	409.806	410.716	0.012	0.001	0.952	0.040	0.000	0.000
1.583	0.996	0.982	0.964	415.916	414.161	409.096	409.625	409.585	410.617	0.013	0.008	0.956	0.040	0.000	0.000
1.625	0.996	0.983	0.964	416.191	414.131	409.050	409.720	409.676	410.644	0.013	0.008	0.916	0.040	0.000	0.000
1.667	0.996	0.984	0.964	416.516	414.167	409.057	409.816	409.784	410.706	0.014	0.006	0.879	0.040	0.000	0.000
1.708	0.996	0.984	0.964	416.794	414.105	409.121	409.838	409.824	410.722	0.015	0.002	0.821	0.040	0.000	0.000
1.750	0.996	0.985	0.964	417.070	414.111	409.052	409.913	409.900	410.744	0.015	0.002	0.800	0.040	0.000	0.000
1.792	0.996	0.985	0.964	417.296	414.041	409.136	410.027	410.017	410.805	0.016	0.002	0.756	0.058	-1.759	-14.528
1.833	0.996	0.986	0.964	417.479	413.999	409.086	410.135	410.140	410.840	0.016	-0.001	0.740	0.060	-0.675	-13.757
1.875	0.996	0.987	0.964	417.715	413.935	409.206	410.256	410.257	410.913	0.016	0.000	0.695	0.065	0.684	-14.290
1.917	0.996	0.987	0.964	417.946	413.859	409.194	410.341	410.345	410.935	0.017	-0.001	0.665	0.068	1.203	-14.374
1.958	0.996	0.987	0.964	418.046	413.774	409.226	410.415	410.432	410.962	0.017	-0.002	0.642	0.069	1.466	-14.445
2.000	0.997	0.988	0.965	418.105	413.716	409.329	410.495	410.525	411.016	0.017	-0.004	0.619	0.070	1.650	-14.340

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APPENDIX D: MATLAB CODE AND CALIBRATION DATA

"fhpsurveys.m"

```
% LT J. Carlson
% 5 Hole Probe Data Conversion
% This program reads the calibration coefficients obtained
% from calibration.m and uses them along with user inputs
% for beta, gamma and delta from the 9 5hole pressure surveys
% conducted to determine X, Phi and Psi values for each survey.
% Carpet plots are then generated to see the change in X, Phi,
% Psi moving from centerline out to the end.

clear
clf
clc

%Set Parameters
L=7;
M=7;
N=6;

c=zeros(1,294);
d=zeros(1,294);
e=zeros(1,294);

C=wk1read('C');
D=wk1read('D');
E=wk1read('E');

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Survey #1

z1=49; %number of measurements recorded
LOC1=zeros(z1,1);
X1=zeros(z1,1);
PHI1=zeros(z1,1);
PSI1=zeros(z1,1);
R1=zeros(z1,6);

load s1bgd.dat
beta1(:,1)=s1bgd(:,1);
gamma1(:,1)=s1bgd(:,2);
delta1(:,1)=s1bgd(:,3);

%Probe location
count=0;
for q=1:z1
   LOC1(q)=count;
   count=count+(.25/6);
end

%solve for X, PHI, PSI
for l=1:z1
```

```
%X
count=1;
  for i=1:L
      for j=1:M
          for k=1:N
              term1(l)=beta1(l)^(k-1);
              term2(l)=gamma1(l)^(j-1);
              term3(l)=delta1(l)^(i-1);
              c(count)=term1(l)*term2(l)*term3(l);
              count=count+1;
          end
      end
  end
  xtemp=c*C;

%Phi
count=1;
  for i=1:L
      for j=1:M
          for k=1:N
              term1(l)=beta1(l)^(k-1);
              term2(l)=gamma1(l)^(j-1);
              term3(l)=delta1(l)^(i-1);
              d(count)=term1(l)*term2(l)*term3(l);
              count=count+1;
          end
      end
  end

  phitemp=d*D;

%Psi
count=1;
  for i=1:L
      for j=1:M
          for k=1:N
              term1(l)=beta1(l)^(k-1);
              term2(l)=gamma1(l)^(j-1);
              term3(l)=delta1(l)^(i-1);
              e(count)=term1(l)*term2(l)*term3(l);
              count=count+1;
          end
      end
  end
  psitemp=e*E;

if xtemp<.04 | abs(phitemp)>15 | abs(psitemp)>15
     xtemp=.04; phitemp=0; psitemp=0;
  end
  X1(l,1)=xtemp;
  PHI1(l,1)=phitemp;
  PSI1(l,1)=psitemp;
  PX1(l,1)=xtemp*cos(phitemp)*sin(psitemp);
  PY1(l,1)=xtemp*sin(phitemp)*sin(psitemp);
end
```

```
R1(:,1)=LOC1(:,1);
R1(:,2)=X1(:,1);
R1(:,3)=PHI1(:,1);
R1(:,4)=PSI1(:,1);
R1(:,5)=PX1(:,1);
R1(:,6)=PY1(:,1);


figure(1)
plot(LOC1,X1,'kd')
%title('Survey 1 - 3/18')
xlabel('Traverse position, y/S')
ylabel('X')
axis([0 2 .04 .09])
grid on

figure(2)
plot(LOC1,PHI1,'k*',LOC1,PSI1,'ko')
%title('Survey 1 - 3/18')
xlabel('Traverse position, y/S')
ylabel('Pitch (PHI) and Yaw (PSI) Sensitivity')
axis([0 2 -15 6])
grid on
legend('PHI','PSI',0)


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
%Survey #2

z2=49;
LOC2=zeros(z2,1);
X2=zeros(z2,1);
PHI2=zeros(z2,1);
PSI2=zeros(z2,1);
R2=zeros(z2,6);

load  s2bgd.dat
beta2(:,1)=s2bgd(:,1);
gamma2(:,1)=s2bgd(:,2);
delta2(:,1)=s2bgd(:,3);

%Probe location
count=0;
for q=1:z2
   LOC2(q)=count;
   count=count+(.25/6);
end


%solve for X, PHI, PSI
for l=1:z2
```

```
%X
count=1;
  for i=1:L
      for j=1:M
          for k=1:N
              term1(1)=beta2(1)^(k-1);
              term2(1)=gamma2(1)^(j-1);
              term3(1)=delta2(1)^(i-1);
              c(count)=term1(1)*term2(1)*term3(1);
              count=count+1;
          end
      end
  end
  xtemp=c*C;

%Phi
count=1;
  for i=1:L
      for j=1:M
          for k=1:N
              term1(1)=beta2(1)^(k-1);
              term2(1)=gamma2(1)^(j-1);
              term3(1)=delta2(1)^(i-1);
              d(count)=term1(1)*term2(1)*term3(1);
              count=count+1;
          end
      end
  end
phitemp=d*D;

%Psi
count=1;
  for i=1:L
      for j=1:M
          for k=1:N
              term1(1)=beta2(1)^(k-1);
              term2(1)=gamma2(1)^(j-1);
              term3(1)=delta2(1)^(i-1);
              e(count)=term1(1)*term2(1)*term3(1);
              count=count+1;
          end
      end
  end
psitemp=e*E;

if xtemp<.04 | abs(phitemp)>15 | abs(psitemp)>15
     xtemp=.04; phitemp=0; psitemp=0;
 end
 X2(1,1)=xtemp;
 PHI2(1,1)=phitemp;
 PSI2(1,1)=psitemp;
 PX2(1,1)=xtemp*cos(phitemp)*sin(psitemp);
 PY2(1,1)=xtemp*sin(phitemp)*sin(psitemp);
end
```

```
R2(:,1)=LOC2(:,1);
R2(:,2)=X2(:,1);
R2(:,3)=PHI2(:,1);
R2(:,4)=PSI2(:,1);
R2(:,5)=PX2(:,1);
R2(:,6)=PY2(:,1);


figure(3)
plot(LOC2,X2,'kd')
%title('Survey 2 - 3/25')
xlabel('Traverse position, y/S')
ylabel('X')
grid on
axis([0 2 .04 .09])

figure(4)
plot(LOC2,PHI2,'k*',LOC2,PSI2,'ko')
%title('Survey 2 - 3/25')
xlabel('Traverse position, y/S')
ylabel('Pitch (PHI) and Yaw (PSI) Sensivity')
grid on
axis([0 2 -15 6])
legend('PHI','PSI',0)


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%The process is repeated for each survey (3 thru 9) by changing the
%variable postscript in order to track data points, ie. PHI3, X3, PSI3
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% CARPET PLOT OF PHI
y(:,1)=R(:,1);
z(:,1)=R(:,3);
for i=1:49
   x(i,1)=0;
end

y(:,2)=R(:,1);
z(:,2)=R(:,6);
for i=1:49
   x(i,2)=-.1;
end

y(:,3)=R(:,1);
z(:,3)=R(:,9);
for i=1:49
   x(i,3)=-.2;
end

y(:,4)=R(:,1);
z(:,4)=R(:,12);
```

```
for i=1:49
   x(i,4)=-.3;
end

y(:,5)=R(:,1);
z(:,5)=R(:,15);
for i=1:49
   x(i,5)=-.353;
end

y(:,6)=R(:,1);
z(:,6)=R(:,18);
for i=1:49
   x(i,6)=-.4034;
end

y(:,7)=R(:,1);
z(:,7)=R(:,21);
for i=1:49
   x(i,7)=-.453;
end

y(:,8)=R(:,1);
z(:,8)=R(:,24);
for i=1:49
   x(i,8)=-.478;
end

y(:,9)=R(:,1);
z(:,9)=R(:,27);
for i=1:49
   x(i,9)=-.491;
end

figure(19)
surf(x,y,z)

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%5
% CARPET PLOT OF PSI
Y(:,1)=R(:,1);
z(:,1)=R(:,4);
for i=1:49
   x(i,1)=0;
end

y(:,2)=R(:,1);
z(:,2)=R(:,7);
for i=1:49
   x(i,2)=-.1;
end

y(:,3)=R(:,1);
z(:,3)=R(:,10);
for i=1:49
   x(i,3)=-.2;
end
```

```
y(:,4)=R(:,1);
z(:,4)=R(:,13);
for i=1:49
   x(i,4)=-.3;
end

y(:,5)=R(:,1);
z(:,5)=R(:,16);
for i=1:49
   x(i,5)=-.353;
end

y(:,6)=R(:,1);
z(:,6)=R(:,19);
for i=1:49
   x(i,6)=-.4034;
end

y(:,7)=R(:,1);
z(:,7)=R(:,22);
for i=1:49
   x(i,7)=-.453;
end

y(:,8)=R(:,1);
z(:,8)=R(:,25);
for i=1:49
   x(i,8)=-.478;
end

y(:,9)=R(:,1);
z(:,9)=R(:,28);
for i=1:49
   x(i,9)=-.491;
end

figure(20)
surf(x,y,z)


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% CARPET PLOT OF X
y(:,1)=R(:,1);
z(:,1)=R(:,2);
for i=1:49
   x(i,1)=0;
end

y(:,2)=R(:,1);
z(:,2)=R(:,5);
for i=1:49
   x(i,2)=-.1;
end

y(:,3)=R(:,1);
z(:,3)=R(:,8);
```

```
for i=1:49
   x(i,3)=-.2;
end

y(:,4)=R(:,1);
z(:,4)=R(:,11);
for i=1:49
   x(i,4)=-.3;
end

y(:,5)=R(:,1);
z(:,5)=R(:,14);
for i=1:49
   x(i,5)=-.353;
end

y(:,6)=R(:,1);
z(:,6)=R(:,17);
for i=1:49
   x(i,6)=-.4034;
end

y(:,7)=R(:,1);
z(:,7)=R(:,20);
for i=1:49
   x(i,7)=-.453;
end

y(:,8)=R(:,1);
z(:,8)=R(:,23);
for i=1:49
   x(i,8)=-.478;
end

y(:,9)=R(:,1);
z(:,9)=R(:,26);
for i=1:49
   x(i,9)=-.491;
end

figure(21)
surf(x,y,z), hold on

% Vector PLOT OF PX/PY
y(:,1)=R(:,1);
px(:,1)=PX1;
py(:,1)=PY1;
for i=1:49
   x(i,1)=0;
end

y(:,2)=R(:,1);
px(:,2)=PX2;
py(:,2)=PY2;
for i=1:49
   x(i,2)=-.1;
end
```

```
y(:,3)=R(:,1);
px(:,3)=PX3;
py(:,3)=PY3;
for i=1:49
   x(i,3)=-.2;
end

y(:,4)=R(:,1);
px(:,4)=PX4;
py(:,4)=PY4;
for i=1:49
   x(i,4)=-.3;
end

y(:,5)=R(:,1);
px(:,5)=PX5;
py(:,5)=PY5;
for i=1:49
   x(i,5)=-.353;
end

y(:,6)=R(:,1);
px(:,6)=PX6;
py(:,6)=PY6;
for i=1:49
   x(i,6)=-.4034;
end

y(:,7)=R(:,1);
px(:,7)=PX7;
py(:,7)=PY7;
for i=1:49
   x(i,7)=-.453;
end

y(:,8)=R(:,1);
px(:,8)=PX8;
py(:,8)=PY8;
for i=1:49
   x(i,8)=-.478;
end

y(:,9)=R(:,1);
px(:,9)=PX9;
py(:,9)=PY9;
for i=1:49
   x(i,9)=-.491;
end

quiver(x,y,px,py)
```

"calibration.m" [Ref. 7]

```
% AA 3802 Final Project (Part 1)
% Calibration.m
% Five-hole Probe Calibration Program
% This program reads data from a reduced data file and computes the
%  calibration coefficients. The calibration coefficients
%  are then output to another data file.

clear
clc

%Set Initial Parameters
L=7;
M=7;
N=6;
c=zeros(294);
d=zeros(294);
e=zeros(294);

%Import Data
data=wk1read('a:reducedproject');
X=data(:,5);
phi=data(:,8);
psi=data(:,9);
beta=data(:,2);
gamma=data(:,3);
delta=data(:,4);

%Calculate C Calibration Coefficients
for t=1:294
count=1;
for i=1:L
for j=1:M
for k=1:N
index(count,1)=i;
index(count,2)=j;
index(count,3)=k;
c(t,count)=beta(t)^(k-1)*gamma(t)^(j-1)*delta(t)^(i-1);
count=count+1;
end
end
end
end
C=c\X;
format long
wk1write('a:C',C)

%Calculate D Calibration Coefficients
for t=1:294
count=1;
for i=1:L
for j=1:M
for k=1:N
d(t,count)=beta(t)^(k-1)*gamma(t)^(j-1)*delta(t)^(i-1);
count=count+1;
```

```
end
end
end
end
D=d\phi;
format long
wk1write('a:D',D)

%Calculate E Calibration Coefficients
for t=1:294
count=1;
for i=1:L
for j=1:M
for k=1:N
e(t,count)=beta(t)^(k-1)*gamma(t)^(j-1)*delta(t)^(i-1);
count=count+1;
end
end
end
end
E=e\psi;
format long
wk1write('a:E',E)

%Output Index for Reference
delete a:index.txt
diary a:index.txt
disp(index)
diary off
```

"reducedproject.dat" reduced calibration data [Ref. 7]

Mach #	Beta	Gamma	Delta	X	Actual Mach	Total Temp	Phi (pitch)	Psi (yaw)
0.10	0.00535	0.57545	0.63048	0.04009	0.08971	558.01640	-15.0	-15.0
0.10	0.00645	0.65800	0.43400	0.04314	0.09655	558.09551	-15.0	-10.0
0.10	0.00572	0.67295	0.32521	0.04075	0.09120	558.15527	-15.0	-5.0
0.10	0.00576	0.65439	0.16993	0.03993	0.08937	558.26777	-15.0	0.0
0.10	0.00559	0.65698	0.01027	0.03950	0.08839	558.36445	-15.0	5.0
0.10	0.00617	0.65803	-0.14264	0.04273	0.09564	558.32930	-15.0	10.0
0.10	0.00525	0.59956	-0.20868	0.03976	0.08898	558.52616	-15.0	15.0
0.10	0.00571	0.41998	0.67201	0.03973	0.08890	558.55079	-10.0	-15.0
0.10	0.00695	0.44812	0.41678	0.04208	0.09419	558.42949	-10.0	-10.0
0.10	0.00581	0.42682	0.26295	0.03920	0.08773	558.41015	-10.0	-5.0
0.10	0.00600	0.45470	0.17931	0.03958	0.08857	558.36622	-10.0	0.0
0.10	0.00568	0.48585	0.11716	0.03927	0.08787	558.50683	-10.0	5.0
0.10	0.00587	0.43343	-0.14809	0.04159	0.09307	558.50683	-10.0	10.0
0.10	0.00592	0.43251	-0.35697	0.04054	0.09072	558.52089	-10.0	15.0
0.10	0.00545	0.16839	0.76603	0.04032	0.09024	558.77579	-5.0	-15.0
0.10	0.00587	0.19776	0.63737	0.04088	0.09149	558.92872	-5.0	-10.0
0.10	0.00614	0.22562	0.29553	0.03816	0.08539	558.84433	-5.0	-5.0
0.10	0.00632	0.17389	0.09457	0.04006	0.08965	558.95509	-5.0	0.0
0.10	0.00588	0.20346	-0.05218	0.03797	0.08497	558.85137	-5.0	5.0
0.10	0.00597	0.27509	-0.41227	0.03854	0.08624	558.76171	-5.0	10.0
0.10	0.00576	0.22096	-0.59568	0.03676	0.08226	558.74414	-5.0	15.0
0.10	0.00622	0.01404	0.62566	0.03856	0.08628	558.77402	0.0	-15.0
0.10	0.00606	0.01949	0.44467	0.03743	0.08377	558.82676	0.0	-10.0
0.10	0.00618	0.03525	0.19425	0.03932	0.08799	558.74765	0.0	-5.0
0.10	0.00554	0.06145	0.11313	0.03686	0.08248	558.88652	0.0	0.0
0.10	0.00528	0.08042	-0.07480	0.03557	0.07958	559.02012	0.0	5.0
0.10	0.00661	0.05866	-0.25413	0.04295	0.09614	558.97969	0.0	10.0
0.10	0.00597	0.07999	-0.54891	0.03898	0.08722	559.12384	0.0	15.0
0.10	0.00596	-0.16016	0.78202	0.04055	0.09075	559.10801	5.0	-15.0
0.10	0.00601	-0.16499	0.53838	0.03934	0.08803	559.04473	5.0	-10.0
0.10	0.00636	-0.11135	0.26320	0.04092	0.09157	558.99375	5.0	-5.0
0.10	0.00601	-0.13312	0.03121	0.03947	0.08833	558.88476	5.0	0.0
0.10	0.00609	-0.12300	-0.16300	0.04013	0.08981	558.91289	5.0	5.0
0.10	0.00609	-0.13470	-0.44660	0.03879	0.08679	558.85312	5.0	10.0
0.10	0.00633	-0.06705	-0.55725	0.04180	0.09355	558.88829	5.0	15.0
0.10	0.00591	-0.32771	0.60281	0.03909	0.08748	559.06055	10.0	-15.0
0.10	0.00611	-0.37304	0.45243	0.04022	0.09002	559.04296	10.0	-10.0
0.10	0.00610	-0.37789	0.20567	0.03816	0.08539	559.05000	10.0	-5.0
0.10	0.00681	-0.31671	0.04120	0.04270	0.09556	559.12031	10.0	0.0
0.10	0.00600	-0.36412	-0.16528	0.03952	0.08843	559.10801	10.0	5.0
0.10	0.00667	-0.30544	-0.30736	0.04277	0.09572	559.29610	10.0	10.0
0.10	0.00576	-0.27738	-0.60036	0.03953	0.08846	559.27676	10.0	15.0
0.10	0.00559	-0.49960	0.54759	0.03994	0.08938	559.28555	15.0	-15.0
0.10	0.00555	-0.53838	0.38711	0.03840	0.08594	559.26094	15.0	-10.0
0.10	0.00610	-0.62626	0.21924	0.03981	0.08909	559.19589	15.0	-5.0
0.10	0.00662	-0.54614	0.08177	0.04202	0.09405	559.13613	15.0	0.0
0.10	0.00583	-0.59936	-0.18577	0.04041	0.09043	559.17305	15.0	5.0
0.10	0.00575	-0.47178	-0.32606	0.04031	0.09020	559.23281	15.0	10.0
0.10	0.00561	-0.55250	-0.55836	0.04077	0.09125	559.35586	15.0	15.0

Mach #	Beta	Gamma	Delta	X	Actual Mach	Total Temp	Phi (pitch)	Psi (yaw)
0.15	0.01447	0.73547	0.54041	0.06695	0.15005	561.15058	-15.0	-15.0
0.15	0.01514	0.69897	0.38763	0.06582	0.14749	561.45116	-15.0	-10.0
0.15	0.01606	0.73758	0.15428	0.06680	0.14971	561.63926	-15.0	-5.0
0.15	0.01629	0.69293	-0.00879	0.06572	0.14726	561.76406	-15.0	0.0
0.15	0.01605	0.72015	-0.13424	0.06574	0.14733	561.96269	-15.0	5.0
0.15	0.01608	0.71404	-0.29441	0.06488	0.14539	562.23339	-15.0	10.0
0.15	0.01511	0.75352	-0.61975	0.06628	0.14854	562.44961	-15.0	15.0
0.15	0.01564	0.43752	0.66230	0.06662	0.14929	563.03671	-10.0	-15.0
0.15	0.01615	0.46425	0.38364	0.06667	0.14940	563.27579	-10.0	-10.0
0.15	0.01614	0.52148	0.14697	0.06764	0.15159	563.38829	-10.0	-5.0
0.15	0.01643	0.48770	0.00030	0.06763	0.15158	563.49024	-10.0	0.0
0.15	0.01632	0.50345	-0.15871	0.06728	0.15077	563.48848	-10.0	5.0
0.15	0.01617	0.44716	-0.33124	0.06596	0.14781	563.46387	-10.0	10.0
0.15	0.01544	0.43489	-0.63770	0.06581	0.14748	563.50430	-10.0	15.0
0.15	0.01603	0.22889	0.68514	0.06578	0.14741	563.69414	-5.0	-15.0
0.15	0.01652	0.20484	0.43397	0.06682	0.14975	563.83829	-5.0	-10.0
0.15	0.01585	0.24400	0.18227	0.06660	0.14925	564.02110	-5.0	-5.0
0.15	0.01618	0.25434	-0.00779	0.06516	0.14601	564.06856	-5.0	0.0
0.15	0.01612	0.23278	-0.16171	0.06688	0.14987	564.28476	-5.0	5.0
0.15	0.01666	0.19112	-0.39368	0.06615	0.14825	564.24259	-5.0	10.0
0.15	0.01572	0.24632	-0.68972	0.06774	0.15182	564.45176	-5.0	15.0
0.15	0.01626	0.04364	0.63458	0.06742	0.15110	564.58183	0.0	-15.0
0.15	0.01621	0.04856	0.44423	0.06774	0.15183	564.58536	0.0	-10.0
0.15	0.01581	0.04225	0.22993	0.06707	0.15030	564.63985	0.0	-5.0
0.15	0.01572	0.05213	-0.00407	0.06716	0.15051	564.55723	0.0	0.0
0.15	0.01624	0.04541	-0.19049	0.06741	0.15107	564.59765	0.0	5.0
0.15	0.01645	0.05010	-0.41002	0.06700	0.15016	564.62930	0.0	10.0
0.15	0.01560	0.06702	-0.68957	0.06617	0.14829	564.68204	0.0	15.0
0.15	0.01569	-0.11848	0.67013	0.06792	0.15222	564.80509	5.0	-15.0
0.15	0.01587	-0.11908	0.44190	0.06776	0.15187	564.92812	5.0	-10.0
0.15	0.01593	-0.12899	0.23428	0.06730	0.15083	564.95098	5.0	-5.0
0.15	0.01571	-0.11226	-0.00474	0.06690	0.14992	565.05293	5.0	0.0
0.15	0.01592	-0.09865	-0.21346	0.06673	0.14955	565.18301	5.0	5.0
0.15	0.01634	-0.09282	-0.41506	0.06636	0.14872	565.31134	5.0	10.0
0.15	0.01575	-0.11036	-0.70339	0.06851	0.15356	565.21991	5.0	15.0
0.15	0.01552	-0.31371	0.60560	0.06772	0.15177	565.17598	10.0	-15.0
0.15	0.01569	-0.33330	0.37145	0.06681	0.14973	565.04589	10.0	-10.0
0.15	0.01536	-0.38282	0.18584	0.06660	0.14926	565.07051	10.0	-5.0
0.15	0.01604	-0.37702	0.03420	0.06802	0.15245	565.05820	10.0	0.0
0.15	0.01606	-0.36311	-0.12335	0.06798	0.15236	565.09512	10.0	5.0
0.15	0.01595	-0.30367	-0.40666	0.06789	0.15215	565.16015	10.0	10.0
0.15	0.01550	-0.28568	-0.69011	0.06886	0.15435	565.22344	10.0	15.0
0.15	0.01470	-0.53932	0.57202	0.06750	0.15127	565.35176	15.0	-15.0
0.15	0.01511	-0.57317	0.34274	0.06685	0.14982	565.44317	15.0	-10.0
0.15	0.01527	-0.57156	0.19051	0.06782	0.15201	565.46426	15.0	-5.0
0.15	0.01606	-0.58621	0.00161	0.06880	0.15420	565.55918	15.0	0.0
0.15	0.01577	-0.57011	-0.14326	0.06878	0.15417	565.55918	15.0	5.0
0.15	0.01508	-0.52419	-0.31977	0.06745	0.15116	565.47128	15.0	10.0
0.15	0.01498	-0.53065	-0.66097	0.06867	0.15392	565.39394	15.0	15.0

Mach #	Beta	Gamma	Delta	X	Actual Mach	Total Temp	Phi (pitch)	Psi (yaw)
0.20	0.02733	0.75752	0.59655	0.08939	0.20068	566.01269	-15.0	-15.0
0.20	0.02754	0.76467	0.33531	0.08890	0.19958	566.32384	-15.0	-10.0
0.20	0.02846	0.78291	0.13348	0.09070	0.20364	566.72637	-15.0	-5.0
0.20	0.02829	0.74843	-0.01678	0.09011	0.20231	567.01464	-15.0	0.0
0.20	0.02837	0.75584	-0.17679	0.09141	0.20527	567.37851	-15.0	5.0
0.20	0.02776	0.74796	-0.33031	0.09080	0.20388	567.82851	-15.0	10.0
0.20	0.02803	0.75816	-0.60815	0.09047	0.20314	568.07637	-15.0	15.0
0.20	0.02783	0.43093	0.68651	0.09041	0.20298	568.54570	-10.0	-15.0
0.20	0.02822	0.53704	0.41417	0.09107	0.20448	568.59491	-10.0	-10.0
0.20	0.02870	0.57551	0.12658	0.08991	0.20185	568.75137	-10.0	-5.0
0.20	0.02968	0.56323	-0.02370	0.09138	0.20518	568.94296	-10.0	0.0
0.20	0.02936	0.51456	-0.15217	0.08912	0.20007	569.09942	-10.0	5.0
0.20	0.02887	0.53011	-0.35816	0.09055	0.20332	569.21894	-10.0	10.0
0.20	0.02789	0.48098	-0.66706	0.09052	0.20325	569.60214	-10.0	15.0
0.20	0.02862	0.21140	0.70711	0.09055	0.20332	569.87286	-5.0	-15.0
0.20	0.02945	0.22681	0.49859	0.09087	0.20404	570.13476	-5.0	-10.0
0.20	0.02947	0.30338	0.20379	0.09103	0.20441	570.30704	-5.0	-5.0
0.20	0.02927	0.33224	-0.00179	0.09064	0.20352	570.54433	-5.0	0.0
0.20	0.02967	0.31206	-0.19194	0.09079	0.20385	570.56015	-5.0	5.0
0.20	0.02871	0.22492	-0.47823	0.09125	0.20490	570.75176	-5.0	10.0
0.20	0.02863	0.25250	-0.68699	0.09131	0.20502	570.76582	-5.0	15.0
0.20	0.02881	0.03118	0.65549	0.09131	0.20504	572.27226	0.0	-15.0
0.20	0.02934	0.03114	0.47110	0.09124	0.20488	572.14043	0.0	-10.0
0.20	0.02879	0.04634	0.29872	0.09019	0.20251	572.23009	0.0	-5.0
0.20	0.02798	0.05136	-0.00040	0.09053	0.20327	572.36366	0.0	0.0
0.20	0.02919	0.03559	-0.26894	0.09161	0.20571	572.39356	0.0	5.0
0.20	0.02837	0.04907	-0.47989	0.09053	0.20327	572.60449	0.0	10.0
0.20	0.02777	0.05003	-0.67674	0.09103	0.20439	572.60449	0.0	15.0
0.20	0.02804	-0.11641	0.67047	0.09132	0.20505	572.64491	5.0	-15.0
0.20	0.02908	-0.11072	0.47323	0.09121	0.20480	572.65723	5.0	-10.0
0.20	0.02874	-0.13703	0.25017	0.09012	0.20233	572.64668	5.0	-5.0
0.20	0.02779	-0.16969	0.00570	0.09062	0.20348	572.65195	5.0	0.0
0.20	0.02877	-0.07809	-0.27720	0.09147	0.20540	572.60801	5.0	5.0
0.20	0.02835	-0.07432	-0.47626	0.08899	0.19977	572.66954	5.0	10.0
0.20	0.02746	-0.07106	-0.66579	0.09021	0.20254	572.63086	5.0	15.0
0.20	0.02750	-0.27964	0.68939	0.09164	0.20577	572.84356	10.0	-15.0
0.20	0.02815	-0.33453	0.42507	0.09106	0.20446	573.04219	10.0	-10.0
0.20	0.02863	-0.39934	0.16590	0.09037	0.20290	573.12128	10.0	-5.0
0.20	0.02855	-0.38346	-0.00302	0.09033	0.20281	573.19336	10.0	0.0
0.20	0.02897	-0.38167	-0.14587	0.09062	0.20347	573.18281	10.0	5.0
0.20	0.02840	-0.24704	-0.47518	0.09141	0.20526	573.21973	10.0	10.0
0.20	0.02762	-0.25108	-0.71713	0.09175	0.20604	573.12305	10.0	15.0
0.20	0.02687	-0.55904	0.65167	0.09137	0.20517	573.03692	15.0	-15.0
0.20	0.02739	-0.64496	0.37652	0.09128	0.20497	573.05625	15.0	-10.0
0.20	0.02837	-0.61954	0.15151	0.09121	0.20482	572.95430	15.0	-5.0
0.20	0.02828	-0.60926	-0.02435	0.09070	0.20365	573.06680	15.0	0.0
0.20	0.02771	-0.58966	-0.16903	0.09173	0.20597	573.04921	15.0	5.0
0.20	0.02736	-0.55637	-0.35641	0.09128	0.20497	573.10019	15.0	10.0
0.20	0.02660	-0.52847	-0.68693	0.09055	0.20331	573.21445	15.0	15.0

Mach #	Beta	Gamma	Delta	X	Actual Mach	Total Temp	Phi (pitch)	Psi (yaw)
0.25	0.04214	0.76574	0.61542	0.11151	0.25090	574.75957	-15.0	-15.0
0.25	0.04308	0.81908	0.34776	0.11126	0.25033	575.12695	-15.0	-10.0
0.25	0.04334	0.78776	0.14468	0.11237	0.25287	575.26231	-15.0	-5.0
0.25	0.04346	0.76680	-0.01300	0.11301	0.25432	575.37832	-15.0	0.0
0.25	0.04308	0.75294	-0.16637	0.11260	0.25338	575.64199	-15.0	5.0
0.25	0.04325	0.77645	-0.35036	0.11288	0.25402	575.91973	-15.0	10.0
0.25	0.04203	0.74116	-0.57045	0.11246	0.25308	576.19394	-15.0	15.0
0.25	0.04310	0.43772	0.68291	0.11206	0.25215	576.86366	-10.0	-15.0
0.25	0.04474	0.51913	0.44012	0.11254	0.25325	577.18183	-10.0	-10.0
0.25	0.04518	0.59974	0.12875	0.11314	0.25463	577.33125	-10.0	-5.0
0.25	0.04531	0.58687	-0.00605	0.11318	0.25471	577.63183	-10.0	0.0
0.25	0.04522	0.58609	-0.12555	0.11282	0.25390	577.75137	-10.0	5.0
0.25	0.04402	0.55527	-0.36742	0.11249	0.25315	577.99747	-10.0	10.0
0.25	0.04322	0.47932	-0.69599	0.11271	0.25365	578.12930	-10.0	15.0
0.25	0.04435	0.23647	0.69956	0.11228	0.25267	578.23301	-5.0	-15.0
0.25	0.04444	0.21342	0.51179	0.11181	0.25158	578.33320	-5.0	-10.0
0.25	0.04510	0.38529	0.19204	0.11247	0.25309	578.35957	-5.0	-5.0
0.25	0.04447	0.37225	-0.01064	0.11291	0.25409	578.64082	-5.0	0.0
0.25	0.04562	0.37813	-0.15032	0.11240	0.25293	578.87813	-5.0	5.0
0.25	0.04472	0.22563	-0.47860	0.11272	0.25368	579.00469	-5.0	10.0
0.25	0.04349	0.26008	-0.69548	0.11295	0.25419	579.15762	-5.0	15.0
0.25	0.04426	0.06322	0.66243	0.11289	0.25404	579.41260	0.0	-15.0
0.25	0.04501	0.05022	0.48891	0.11285	0.25397	579.56015	0.0	-10.0
0.25	0.04446	0.04947	0.30345	0.11277	0.25378	579.64805	0.0	-5.0
0.25	0.04419	0.12614	0.01668	0.11301	0.25433	579.68671	0.0	0.0
0.25	0.04478	0.05606	-0.27483	0.11362	0.25572	579.63046	0.0	5.0
0.25	0.04448	0.05356	-0.49113	0.11334	0.25508	579.62695	0.0	10.0
0.25	0.04352	0.06601	-0.66307	0.11338	0.25517	579.75351	0.0	15.0
0.25	0.04347	-0.11888	0.67745	0.11277	0.25379	579.92930	5.0	-15.0
0.25	0.04510	-0.08410	0.49222	0.11375	0.25601	580.16485	5.0	-10.0
0.25	0.04524	-0.12026	0.31006	0.11350	0.25545	580.25801	5.0	-5.0
0.25	0.04451	-0.22143	0.01210	0.11326	0.25490	580.39161	5.0	0.0
0.25	0.04444	-0.08928	-0.31161	0.11267	0.25354	580.45664	5.0	5.0
0.25	0.04460	-0.06683	-0.47704	0.11307	0.25447	580.48829	5.0	10.0
0.25	0.04297	-0.07037	-0.66274	0.11311	0.25456	580.45488	5.0	15.0
0.25	0.04295	-0.29816	0.67813	0.11356	0.25559	580.39863	10.0	-15.0
0.25	0.04371	-0.29190	0.47371	0.11328	0.25495	580.38985	10.0	-10.0
0.25	0.04461	-0.43851	0.14197	0.11382	0.25617	580.31777	10.0	-5.0
0.25	0.04430	-0.41143	0.00366	0.11278	0.25381	580.32832	10.0	0.0
0.25	0.04477	-0.41575	-0.14273	0.11326	0.25491	580.46192	10.0	5.0
0.25	0.04343	-0.23919	-0.50127	0.11290	0.25408	580.42324	10.0	10.0
0.25	0.04275	-0.25552	-0.71099	0.11304	0.25440	580.62188	10.0	15.0
0.25	0.04215	-0.56020	0.67695	0.11270	0.25362	580.74668	15.0	-15.0
0.25	0.04363	-0.63222	0.39961	0.11316	0.25468	580.83808	15.0	-10.0
0.25	0.04383	-0.64413	0.16892	0.11355	0.25557	580.89961	15.0	-5.0
0.25	0.04326	-0.59904	0.01113	0.11291	0.25410	580.90839	15.0	0.0
0.25	0.04411	-0.63917	-0.14272	0.11365	0.25578	580.79414	15.0	5.0
0.25	0.04353	-0.59888	-0.37996	0.11372	0.25594	580.74317	15.0	10.0
0.25	0.04189	-0.50215	-0.67611	0.11338	0.25516	580.75372	15.0	15.0

Mach #	Beta	Gamma	Delta	X	Actual Mach	Total Temp	Phi (pitch)	Psi (yaw)
0.30	0.05774	0.72981	0.57208	0.13355	0.30133	585.43829	-15.0	-15.0
0.30	0.06050	0.77240	0.33842	0.13411	0.30260	585.78106	-15.0	-10.0
0.30	0.06169	0.76464	0.17123	0.13466	0.30388	585.90411	-15.0	-5.0
0.30	0.06237	0.73395	0.00225	0.13372	0.30173	585.93046	-15.0	0.0
0.30	0.06103	0.69069	-0.16418	0.13396	0.30226	586.20469	-15.0	5.0
0.30	0.06014	0.73038	-0.33371	0.13407	0.30253	586.40860	-15.0	10.0
0.30	0.05749	0.72319	-0.55089	0.13422	0.30287	586.67402	-15.0	15.0
0.30	0.06141	0.44530	0.70118	0.13361	0.30146	587.23476	-10.0	-15.0
0.30	0.06327	0.54106	0.42758	0.13373	0.30175	587.20137	-10.0	-10.0
0.30	0.06328	0.58097	0.13364	0.13363	0.30151	587.18378	-10.0	-5.0
0.30	0.06351	0.56983	-0.01136	0.13400	0.30235	587.45098	-10.0	0.0
0.30	0.06342	0.57736	-0.14262	0.13413	0.30266	588.04687	-10.0	5.0
0.30	0.06258	0.53174	-0.35073	0.13351	0.30124	588.15411	-10.0	10.0
0.30	0.06102	0.47253	-0.66428	0.13501	0.30469	588.04161	-10.0	15.0
0.30	0.06199	0.24413	0.67935	0.13391	0.30216	587.82012	-5.0	-15.0
0.30	0.06315	0.22520	0.49107	0.13397	0.30230	587.80606	-5.0	-10.0
0.30	0.06380	0.39135	0.20090	0.13392	0.30218	588.02402	-5.0	-5.0
0.30	0.06258	0.40072	-0.01420	0.13442	0.30332	588.14884	-5.0	0.0
0.30	0.06387	0.40953	-0.17981	0.13468	0.30393	588.35098	-5.0	5.0
0.30	0.06286	0.24883	-0.49759	0.13472	0.30402	588.40019	-5.0	10.0
0.30	0.06185	0.26313	-0.69080	0.13477	0.30412	588.27188	-5.0	15.0
0.30	0.06185	0.06825	0.64004	0.13412	0.30264	588.20683	0.0	-15.0
0.30	0.06272	0.07028	0.47355	0.13455	0.30362	588.17872	0.0	-10.0
0.30	0.06129	0.07957	0.22990	0.13452	0.30355	588.28594	0.0	-5.0
0.30	0.05955	0.11887	-0.02348	0.13378	0.30186	588.32286	0.0	0.0
0.30	0.06186	0.06729	-0.29228	0.13402	0.30241	588.50039	0.0	5.0
0.30	0.06303	0.07637	-0.48932	0.13460	0.30373	588.70957	0.0	10.0
0.30	0.06115	0.08823	-0.66909	0.13487	0.30437	588.70606	0.0	15.0
0.30	0.06112	-0.08495	0.65366	0.13408	0.30254	588.62168	5.0	-15.0
0.30	0.06206	-0.05340	0.47578	0.13442	0.30332	588.63574	5.0	-10.0
0.30	0.06292	-0.08433	0.29246	0.13467	0.30391	588.54433	5.0	-5.0
0.30	0.06136	-0.24367	-0.00478	0.13407	0.30253	588.51796	5.0	0.0
0.30	0.06220	-0.08548	-0.31366	0.13416	0.30272	588.45997	5.0	5.0
0.30	0.06182	-0.06756	-0.44571	0.13415	0.30269	588.67442	5.0	10.0
0.30	0.06219	-0.07909	-0.53824	0.13452	0.30356	588.75351	5.0	15.0
0.30	0.05942	-0.26706	0.63533	0.13414	0.30268	589.12265	10.0	-15.0
0.30	0.06105	-0.22291	0.49703	0.13429	0.30303	589.05411	10.0	-10.0
0.30	0.06430	-0.40544	0.28654	0.13439	0.30325	589.02949	10.0	-5.0
0.30	0.06465	-0.38482	0.17849	0.13459	0.30371	588.83437	10.0	0.0
0.30	0.06601	-0.39421	0.11073	0.13468	0.30392	588.81152	10.0	5.0
0.30	0.06635	-0.19984	-0.12458	0.13442	0.30332	588.72890	10.0	10.0
0.30	0.06701	-0.21730	-0.20661	0.13453	0.30357	588.70079	10.0	15.0
0.30	0.05317	-0.52064	0.42807	0.13371	0.30170	588.99786	15.0	-15.0
0.30	0.05835	-0.60695	0.28049	0.13402	0.30239	589.05586	15.0	-10.0
0.30	0.06122	-0.61842	0.17691	0.13367	0.30161	589.06817	15.0	-5.0
0.30	0.06203	-0.58201	0.08859	0.13465	0.30385	588.94161	15.0	0.0
0.30	0.06346	-0.57755	0.00691	0.13399	0.30235	588.99786	15.0	5.0
0.30	0.06453	-0.54479	-0.11586	0.13397	0.30230	588.92226	15.0	10.0
0.30	0.06446	-0.43792	-0.26211	0.13372	0.30172	588.67442	15.0	15.0

Mach #	Beta	Gamma	Delta	X	Actual Mach	Total Temp	Phi (pitch)	Psi (yaw)
0.35	0.06983	0.80557	0.22661	0.15515	0.35119	590.15274	-15.0	-15.0
0.35	0.07458	0.79181	0.09679	0.15572	0.35250	590.21074	-15.0	-10.0
0.35	0.08002	0.75176	0.06531	0.15591	0.35294	590.41113	-15.0	-5.0
0.35	0.08144	0.70341	-0.02561	0.15608	0.35334	590.47089	-15.0	0.0
0.35	0.08240	0.68958	-0.09678	0.15664	0.35463	590.58866	-15.0	5.0
0.35	0.08427	0.71274	-0.17915	0.15563	0.35228	590.73106	-15.0	10.0
0.35	0.08178	0.66076	-0.26474	0.15522	0.35134	590.71348	-15.0	15.0
0.35	0.07501	0.49633	0.37970	0.15523	0.35135	590.92442	-10.0	-15.0
0.35	0.08131	0.56324	0.25956	0.15510	0.35106	591.00704	-10.0	-10.0
0.35	0.08531	0.57929	0.15367	0.15523	0.35135	591.06680	-10.0	-5.0
0.35	0.08630	0.57000	0.06729	0.15557	0.35215	591.24082	-10.0	0.0
0.35	0.08790	0.55452	-0.00424	0.15563	0.35230	591.28652	-10.0	5.0
0.35	0.08656	0.50022	-0.06153	0.15580	0.35270	591.24433	-10.0	10.0
0.35	0.08526	0.44128	-0.17913	0.15545	0.35188	591.04043	-10.0	15.0
0.35	0.07748	0.27676	0.43260	0.15549	0.35198	590.97714	-5.0	-15.0
0.35	0.07981	0.22088	0.31155	0.15555	0.35211	590.91738	-5.0	-10.0
0.35	0.08551	0.39438	0.20195	0.15554	0.35209	590.75918	-5.0	-5.0
0.35	0.08704	0.40841	0.15108	0.15593	0.35299	590.57988	-5.0	0.0
0.35	0.08924	0.40800	0.06014	0.15601	0.35316	590.43223	-5.0	5.0
0.35	0.08989	0.24051	-0.15845	0.15603	0.35322	590.21074	-5.0	10.0
0.35	0.09109	0.24347	-0.23943	0.15626	0.35375	590.02089	-5.0	15.0
0.35	0.07866	0.06855	0.45447	0.15522	0.35134	589.92774	0.0	-15.0
0.35	0.08072	0.07863	0.34042	0.15512	0.35112	590.05957	0.0	-10.0
0.35	0.08064	0.06803	0.26528	0.15546	0.35190	589.81875	0.0	-5.0
0.35	0.08159	0.10426	0.21443	0.15553	0.35207	589.82579	0.0	0.0
0.35	0.08355	0.05462	-0.23705	0.15587	0.35285	589.63418	0.0	5.0
0.35	0.08637	0.08328	-0.34434	0.15607	0.35331	589.53926	0.0	10.0
0.35	0.08691	0.09578	-0.37489	0.15657	0.35448	589.43378	0.0	15.0
0.35	0.07347	-0.08636	0.26253	0.15615	0.35350	589.23692	5.0	-15.0
0.35	0.08255	-0.03708	0.47325	0.15613	0.35345	589.25274	5.0	-10.0
0.35	0.08366	-0.04759	0.37964	0.15601	0.35316	589.04003	5.0	-5.0
0.35	0.08623	-0.16113	0.35289	0.15641	0.35409	589.01366	5.0	0.0
0.35	0.09022	-0.04543	0.08623	0.15650	0.35432	588.99259	5.0	5.0
0.35	0.09159	-0.04625	0.00301	0.15554	0.35209	588.81503	5.0	10.0
0.35	0.09369	-0.05015	-0.05719	0.15698	0.35544	588.82558	5.0	15.0
0.35	0.07748	-0.25165	0.55976	0.15541	0.35178	588.68848	10.0	-15.0
0.35	0.08029	-0.20127	0.43739	0.15573	0.35253	588.69902	10.0	-10.0
0.35	0.08670	-0.36317	0.31906	0.15585	0.35281	588.55488	10.0	-5.0
0.35	0.08803	-0.35865	0.25662	0.15584	0.35278	588.63926	10.0	0.0
0.35	0.08966	-0.33059	0.15964	0.15591	0.35294	588.47579	10.0	5.0
0.35	0.08953	-0.15026	-0.03249	0.15569	0.35242	588.43183	10.0	10.0
0.35	0.09189	-0.20990	-0.11920	0.15658	0.35450	588.42128	10.0	15.0
0.35	0.07391	-0.47151	0.50876	0.15619	0.35360	588.35274	15.0	-15.0
0.35	0.08040	-0.56714	0.36961	0.15633	0.35391	588.36680	15.0	-10.0
0.35	0.08419	-0.57837	0.26518	0.15629	0.35382	588.23671	15.0	-5.0
0.35	0.08663	-0.55289	0.17941	0.15597	0.35309	588.30878	15.0	0.0
0.35	0.08803	-0.55098	0.08920	0.15603	0.35322	588.25253	15.0	5.0
0.35	0.08830	-0.50565	-0.01017	0.15671	0.35479	588.24375	15.0	10.0
0.35	0.08845	-0.39373	-0.17259	0.15589	0.35290	588.06796	15.0	15.0

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APPENDIX E : LDV REDUCED DATA

Inlet Surveys

Station 1 - Location 1				**S100**						
Vref =			**71.8699**	**m/s**						
Blade spacing (S) =			**152.4**	**mm**						
z(mm)	**x(mm)**	**y(mm)**	**y/S**	**W/Vref**	**U/Vref**	**V/Vref**	**Tu**	**Tv**	**Re Stress**	**Corr.**
0.000	-36.573	-76.200	-0.5000	1.0357	0.8068	0.6494	1.7303	1.7055	0.0523	0.0343
0.000	-36.573	-68.700	-0.4508	1.0320	0.8048	0.6460	2.0036	1.8851	0.1529	0.0784
0.000	-36.573	-61.200	-0.4016	1.0305	0.8017	0.6474	1.9678	1.7102	0.2018	0.1161
0.000	-36.573	-53.700	-0.3524	1.0283	0.7973	0.6494	1.8821	1.9998	0.1442	0.0741
0.000	-36.573	-46.200	-0.3031	1.0188	0.7882	0.6455	1.6589	1.9407	0.0644	0.0387
0.000	-36.573	-38.700	-0.2539	1.0073	0.7753	0.6431	1.4916	1.9180	0.0940	0.0636
0.000	-36.573	-31.199	-0.2047	1.0011	0.7649	0.6458	1.5268	1.8550	0.1228	0.0839
0.000	-36.573	-23.699	-0.1555	0.9967	0.7552	0.6505	1.6016	1.7330	0.0676	0.0471
0.000	-36.573	-16.199	-0.1063	0.9983	0.7497	0.6591	1.7111	1.7623	0.1061	0.0681
0.000	-36.573	-8.699	-0.0571	1.0061	0.7500	0.6707	1.7862	1.8134	0.0597	0.0357
0.000	-36.573	-1.199	-0.0079	1.0207	0.7564	0.6854	1.8768	1.6762	0.1329	0.0818
0.000	-36.573	6.299	0.0413	1.0340	0.7650	0.6955	1.6787	1.8325	0.0680	0.0428
0.000	-36.573	13.800	0.0906	1.0435	0.7729	0.7010	1.5937	1.7708	0.1992	0.1366
0.000	-36.573	21.300	0.1398	1.0463	0.7810	0.6962	1.6007	1.7439	0.0998	0.0692
0.000	-36.573	28.800	0.1890	1.0555	0.7931	0.6964	1.6217	1.7114	0.0919	0.0641
0.000	-36.573	36.299	0.2382	1.0589	0.8040	0.6891	1.7204	1.6755	0.1822	0.1224
0.000	-36.573	43.799	0.2874	1.0603	0.8115	0.6825	1.8605	1.6604	0.0828	0.0519
0.000	-36.573	51.299	0.3366	1.0585	0.8168	0.6733	1.8336	1.8495	0.2561	0.1462
0.000	-36.573	58.799	0.3858	1.0557	0.8179	0.6675	1.6073	1.6938	0.1026	0.0730
0.000	-36.573	66.299	0.4350	1.0494	0.8168	0.6589	1.5391	1.7455	0.1209	0.0871
0.000	-36.573	73.799	0.4842	1.0366	0.8098	0.6470	1.5345	1.6703	0.1118	0.0844
0.000	-36.573	81.299	0.5335	1.0308	0.8086	0.6393	1.6965	1.8003	0.0586	0.0372
0.000	-36.573	88.799	0.5827	1.0245	0.8060	0.6325	1.8828	1.6948	0.1892	0.1148
0.000	-36.573	96.299	0.6319	1.0269	0.8077	0.6341	1.7389	1.8353	0.2042	0.1239
0.000	-36.573	103.799	0.6811	1.0170	0.7966	0.6323	1.5904	1.8492	0.1241	0.0817
0.000	-36.573	111.299	0.7303	1.0040	0.7831	0.6282	1.6244	2.0690	0.1742	0.1003
0.000	-36.573	118.799	0.7795	0.9944	0.7709	0.6282	1.6239	1.8360	0.0752	0.0488
0.000	-36.573	126.299	0.8287	0.9919	0.7633	0.6334	1.6163	1.7625	0.1293	0.0879
0.000	-36.573	133.800	0.8780	0.9922	0.7563	0.6422	1.8459	1.7372	0.1246	0.0752
0.000	-36.573	141.300	0.9272	0.9984	0.7553	0.6528	1.8152	1.6329	0.1441	0.0941
0.000	-36.573	148.800	0.9764	1.0094	0.7569	0.6678	1.8794	1.6519	0.1029	0.0642
0.000	-36.573	156.300	1.0256	1.0224	0.7630	0.6805	1.7082	1.8583	0.0458	0.0280
0.000	-36.573	163.800	1.0748	1.0365	0.7737	0.6898	1.6289	1.8103	0.0210	0.0138
0.000	-36.573	171.300	1.1240	1.0473	0.7864	0.6917	1.6249	1.6358	-0.0524	-0.0381
0.000	-36.573	178.800	1.1732	1.0519	0.7948	0.6890	1.6067	1.5844	-0.0246	-0.0187
0.000	-36.573	186.300	1.2224	1.0568	0.8053	0.6844	1.6174	1.6328	0.0881	0.0646
0.000	-36.573	193.800	1.2717	1.0608	0.8158	0.6780	1.7478	1.5921	0.0455	0.0316
0.000	-36.573	201.300	1.3209	1.0606	0.8214	0.6709	1.7441	1.6290	0.0471	0.0321
0.000	-36.573	208.800	1.3701	1.0573	0.8236	0.6630	1.6918	1.8087	0.0744	0.0471
0.000	-36.573	216.300	1.4193	1.0502	0.8206	0.6555	1.5460	1.7555	0.0642	0.0458
0.000	-36.573	223.800	1.4685	1.0389	0.8147	0.6446	1.4920	1.6643	0.0618	0.0482
0.000	-36.573	231.300	1.5177	1.0309	0.8092	0.6387	1.5825	1.6755	0.0588	0.0430

Station 1 - Location 2					S101					
Vref =			71.8699	m/s						
Blade spacing (S) =			152.4	mm						

z(mm)	x(mm)	y(mm)	y/S	W/Vref	U/Vref	V/Vref	Tu	Tv	Re Stress	Corr.
-25.399	-36.573	-76.200	-0.5000	1.0453	0.8143	0.6555	2.1647	1.9592	0.1878	0.0857
-25.399	-36.573	-68.700	-0.4508	1.0434	0.8126	0.6546	2.0968	1.8607	0.2301	0.1142
-25.399	-36.573	-61.200	-0.4016	1.0407	0.8114	0.6518	2.0107	1.9191	0.1560	0.0782
-25.399	-36.573	-53.700	-0.3524	1.0375	0.8077	0.6512	1.8237	2.1110	0.2605	0.1310
-25.399	-36.573	-46.200	-0.3031	1.0234	0.7935	0.6463	1.6590	2.0341	0.1271	0.0729
-25.399	-36.573	-38.700	-0.2539	1.0111	0.7814	0.6417	1.7851	1.8595	0.1888	0.1101
-25.399	-36.573	-31.199	-0.2047	1.0033	0.7699	0.6434	1.7520	1.7583	0.1326	0.0833
-25.399	-36.573	-23.699	-0.1555	1.0034	0.7657	0.6485	1.9443	2.0646	0.1301	0.0627
-25.399	-36.573	-16.199	-0.1063	1.0051	0.7582	0.6598	1.9097	1.6516	0.1669	0.1024
-25.399	-36.573	-8.699	-0.0571	1.0205	0.7634	0.6772	2.1020	1.6655	0.1563	0.0864
-25.399	-36.573	-1.199	-0.0079	1.0333	0.7670	0.6924	1.8827	1.8131	-0.0470	-0.0267
-25.399	-36.573	6.299	0.0413	1.0448	0.7731	0.7027	1.8693	1.9325	0.2191	0.1174
-25.399	-36.573	13.800	0.0906	1.0523	0.7808	0.7054	1.6422	1.9492	0.1227	0.0742
-25.399	-36.573	21.300	0.1398	1.0583	0.7904	0.7037	1.6841	1.6427	0.0240	0.0168
-25.399	-36.573	28.800	0.1890	1.0681	0.8068	0.6999	1.8073	1.6813	0.0409	0.0261
-25.399	-36.573	36.299	0.2382	1.0788	0.8237	0.6966	2.2659	1.6598	0.2413	0.1242
-25.399	-36.573	43.799	0.2874	1.0857	0.8344	0.6946	1.9850	1.8432	0.1590	0.0841
-25.399	-36.573	51.299	0.3366	1.0822	0.8363	0.6868	1.8016	2.0145	0.2668	0.1423
-25.399	-36.573	58.799	0.3858	1.0703	0.8310	0.6745	1.9124	2.0456	0.3029	0.1499
-25.399	-36.573	66.299	0.4350	1.0566	0.8245	0.6607	1.7154	1.9910	0.2481	0.1406
-25.399	-36.573	73.799	0.4842	1.0486	0.8190	0.6548	1.6227	1.6911	0.1740	0.1228
-25.399	-36.573	81.299	0.5335	1.0447	0.8201	0.6471	1.8550	1.6035	0.1446	0.0941
-25.399	-36.573	88.799	0.5827	1.0457	0.8242	0.6436	2.2920	2.1951	0.1688	0.0650
-25.399	-36.573	96.299	0.6319	1.0387	0.8167	0.6418	2.0206	1.8519	0.1432	0.0741
-25.399	-36.573	103.799	0.6811	1.0267	0.8047	0.6376	1.7442	2.0212	0.2421	0.1329
-25.399	-36.573	111.299	0.7303	1.0131	0.7903	0.6339	1.8545	1.9620	0.1692	0.0900
-25.399	-36.573	118.799	0.7795	1.0009	0.7765	0.6315	1.7999	1.8042	0.0870	0.0519
-25.399	-36.573	126.299	0.8287	1.0001	0.7717	0.6361	2.1096	1.7257	0.1769	0.0941
-25.399	-36.573	133.800	0.8780	1.0069	0.7715	0.6470	2.1600	1.8413	0.2853	0.1389
-25.399	-36.573	141.300	0.9272	1.0180	0.7723	0.6633	2.1149	1.7999	0.2323	0.1181
-25.399	-36.573	148.800	0.9764	1.0271	0.7727	0.6767	2.2483	1.8513	0.2832	0.1317
-25.399	-36.573	156.300	1.0256	1.0373	0.7763	0.6880	1.8363	2.3748	0.0680	0.0302
-25.399	-36.573	163.800	1.0748	1.0467	0.7818	0.6960	1.6494	1.7863	0.1164	0.0765
-25.399	-36.573	171.300	1.1240	1.0558	0.7896	0.7010	1.6222	1.7171	0.1390	0.0966
-25.399	-36.573	178.800	1.1732	1.0600	0.7985	0.6971	1.6553	1.5984	0.1110	0.0812
-25.399	-36.573	186.300	1.2224	1.0654	0.8081	0.6943	1.7846	1.6565	-0.0070	-0.0046
-25.399	-36.573	193.800	1.2717	1.0682	0.8181	0.6870	1.8755	1.8254	0.1194	0.0675
-25.399	-36.573	201.300	1.3209	1.0740	0.8306	0.6809	2.0309	1.9319	0.1409	0.0695
-25.399	-36.573	208.800	1.3701	1.0712	0.8327	0.6738	1.8602	1.8914	0.0537	0.0296
-25.399	-36.573	216.300	1.4193	1.0596	0.8283	0.6607	1.8586	1.8624	0.2060	0.1152
-25.399	-36.573	223.800	1.4685	1.0458	0.8202	0.6489	1.5849	1.6608	0.0917	0.0675
-25.399	-36.573	231.300	1.5177	1.0353	0.8133	0.6405	1.7440	1.6454	0.1444	0.0974

Station 1 - Location 3				S102						
Vref =		72.3296	m/s							
Blade spacing (S) =		152.4	mm							
z(mm)	**x(mm)**	**y(mm)**	**y/S**	**W/Vref**	**U/Vref**	**V/Vref**	**Tu**	**Tv**	**Re Stress**	**Corr.**
-50.799	-36.573	-76.200	-0.5000	1.0332	0.8014	0.6522	1.8414	1.8754	0.1166	0.0646
-50.799	-36.573	-68.700	-0.4508	1.0283	0.7970	0.6497	1.8817	1.9945	0.0654	0.0333
-50.799	-36.573	-61.200	-0.4016	1.0181	0.7892	0.6431	1.7977	2.0499	0.1784	0.0926
-50.799	-36.573	-53.700	-0.3524	1.0055	0.7773	0.6379	1.9225	2.0446	0.1344	0.0654
-50.799	-36.573	-46.200	-0.3031	1.0058	0.7774	0.6382	2.1016	1.9713	0.2258	0.1042
-50.799	-36.573	-38.700	-0.2539	1.0058	0.7742	0.6421	2.0290	1.7846	0.0862	0.0455
-50.799	-36.573	-31.199	-0.2047	1.0088	0.7695	0.6523	2.0221	1.7642	0.1148	0.0615
-50.799	-36.573	-23.699	-0.1555	1.0114	0.7706	0.6550	2.1105	1.7049	-0.0130	-0.0069
-50.799	-36.573	-16.199	-0.1063	1.0169	0.7677	0.6668	2.1134	2.1561	0.1801	0.0755
-50.799	-36.573	-8.699	-0.0571	1.0182	0.7615	0.6760	1.8965	1.9995	0.1318	0.0665
-50.799	-36.573	-1.199	-0.0079	1.0187	0.7584	0.6802	1.8344	2.0052	0.2255	0.1172
-50.799	-36.573	6.299	0.0413	1.0266	0.7640	0.6857	1.8468	1.9294	0.1188	0.0637
-50.799	-36.573	13.800	0.0906	1.0396	0.7737	0.6944	2.1507	1.8098	0.0527	0.0259
-50.799	-36.573	21.300	0.1398	1.0549	0.7888	0.7004	1.9055	1.6377	0.0525	0.0322
-50.799	-36.573	28.800	0.1890	1.0677	0.8038	0.7029	2.1034	1.6633	0.1503	0.0821
-50.799	-36.573	36.299	0.2382	1.0745	0.8163	0.6988	1.9001	3.1124	0.0272	0.0088
-50.799	-36.573	43.799	0.2874	1.0737	0.8226	0.6901	1.6935	1.7772	0.0170	0.0108
-50.799	-36.573	51.299	0.3366	1.0694	0.8243	0.6813	1.6630	1.8535	0.0853	0.0529
-50.799	-36.573	58.799	0.3858	1.0520	0.8169	0.6629	1.6880	1.6960	0.0863	0.0576
-50.799	-36.573	66.299	0.4350	1.0476	0.8168	0.6560	1.7528	1.7291	0.0071	0.0045
-50.799	-36.573	73.799	0.4842	1.0430	0.8158	0.6499	1.6784	1.7451	0.0357	0.0233
-50.799	-36.573	81.299	0.5335	1.0410	0.8146	0.6481	1.8220	1.7494	0.0982	0.0589
-50.799	-36.573	88.799	0.5827	1.0374	0.8112	0.6467	2.0029	1.6826	0.1220	0.0692
-50.799	-36.573	96.299	0.6319	1.0345	0.8083	0.6457	2.1358	1.7880	0.2561	0.1282
-50.799	-36.573	103.799	0.6811	1.0316	0.8029	0.6478	1.9233	1.8307	0.1145	0.0621
-50.799	-36.573	111.299	0.7303	1.0178	0.7895	0.6423	1.8150	1.9935	0.2579	0.1363
-50.799	-36.573	118.799	0.7795	0.9952	0.7715	0.6286	1.7794	2.7886	0.2481	0.0956
-50.799	-36.573	126.299	0.8287	0.9989	0.7672	0.6396	1.9509	1.6961	0.1510	0.0872
-50.799	-36.573	133.800	0.8780	1.0012	0.7636	0.6475	2.2451	1.8289	0.1556	0.0724
-50.799	-36.573	141.300	0.9272	1.0140	0.7662	0.6641	2.2494	1.8896	0.1960	0.0881
-50.799	-36.573	148.800	0.9764	1.0219	0.7669	0.6754	1.9696	1.9225	0.2586	0.1305
-50.799	-36.573	156.300	1.0256	1.0290	0.7666	0.6864	1.7936	5.9624	0.7703	0.1377
-50.799	-36.573	163.800	1.0748	1.0275	0.7680	0.6826	1.8905	1.6428	0.1581	0.0973
-50.799	-36.573	171.300	1.1240	1.0434	0.7827	0.6900	1.9658	1.6173	0.0748	0.0450
-50.799	-36.573	178.800	1.1732	1.0558	0.7986	0.6906	2.0075	1.7708	0.1254	0.0674
-50.799	-36.573	186.300	1.2224	1.0628	0.8099	0.6882	2.2689	1.7477	0.2282	0.1100
-50.799	-36.573	193.800	1.2717	1.0686	0.8192	0.6862	2.2976	1.7938	0.2405	0.1115
-50.799	-36.573	201.300	1.3209	1.0730	0.8282	0.6822	2.0413	1.8960	0.1952	0.0964
-50.799	-36.573	208.800	1.3701	1.0624	0.8232	0.6716	1.7470	1.8474	0.1674	0.0992
-50.799	-36.573	216.300	1.4193	1.0573	0.8221	0.6649	1.8319	3.4183	0.2256	0.0689
-50.799	-36.573	223.800	1.4685	1.0360	0.8134	0.6417	1.8523	2.9563	0.3123	0.1090
-50.799	-36.573	231.300	1.5177	1.0321	0.8102	0.6393	1.8881	1.6437	0.1437	0.0885

Station 1 - Location 4 **S103**

Vref = **71.5538 m/s**

Blade spacing (S) = **152.4 mm**

z(mm)	x(mm)	y(mm)	y/S	W/Vref	U/Vref	V/Vref	Tu	Tv	Re Stress	Corr.
-76.200	-36.573	-76.200	-0.5000	1.0045	0.7773	0.6363	3.4273	2.7823	0.5819	0.1192
-76.200	-36.573	-68.700	-0.4508	1.0022	0.7761	0.6342	2.6776	2.4921	0.0413	0.0121
-76.200	-36.573	-61.200	-0.4016	0.9970	0.7709	0.6323	2.8747	2.4631	0.0509	0.0140
-76.200	-36.573	-53.700	-0.3524	0.9893	0.7638	0.6287	2.5741	2.4157	0.2353	0.0739
-76.200	-36.573	-46.200	-0.3031	0.9815	0.7536	0.6288	2.6660	2.6431	0.5120	0.1419
-76.200	-36.573	-38.700	-0.2539	0.9836	0.7503	0.6361	3.6727	2.4966	0.5451	0.1161
-76.200	-36.573	-31.199	-0.2047	0.9875	0.7489	0.6438	3.2674	2.4478	0.3275	0.0800
-76.200	-36.573	-23.699	-0.1555	0.9913	0.7518	0.6462	3.6036	2.5492	0.2571	0.0547
-76.200	-36.573	-16.199	-0.1063	0.9919	0.7482	0.6513	2.8903	2.9076	0.4178	0.0971
-76.200	-36.573	-8.699	-0.0571	0.9890	0.7387	0.6576	2.9237	2.8833	0.1187	0.0275
-76.200	-36.573	-1.199	-0.0079	1.0016	0.7447	0.6699	2.4906	2.7164	0.3384	0.0977
-76.200	-36.573	6.299	0.0413	1.0117	0.7482	0.6809	3.0695	2.1665	0.2306	0.0677
-76.200	-36.573	13.800	0.0906	1.0300	0.7614	0.6937	2.8566	2.1492	0.2085	0.0663
-76.200	-36.573	21.300	0.1398	1.0426	0.7776	0.6946	3.4163	2.0751	0.3159	0.0870
-76.200	-36.573	28.800	0.1890	1.0643	0.8017	0.7000	2.9294	2.2014	0.2618	0.0793
-76.200	-36.573	36.299	0.2382	1.0608	0.8059	0.6897	2.7895	2.4152	0.0379	0.0110
-76.200	-36.573	43.799	0.2874	1.0482	0.8034	0.6733	2.7818	2.6439	0.1731	0.0460
-76.200	-36.573	51.299	0.3366	1.0397	0.8017	0.6620	3.1569	2.6731	0.0673	0.0156
-76.200	-36.573	58.799	0.3858	1.0400	0.8134	0.6480	2.6346	4.3558	0.4847	0.0825
-76.200	-36.573	66.299	0.4350	1.0414	0.8124	0.6515	2.4971	2.1127	0.3827	0.1417
-76.200	-36.573	73.799	0.4842	1.0337	0.8110	0.6410	2.4601	1.9735	0.3381	0.1360
-76.200	-36.573	81.299	0.5335	1.0210	0.8017	0.6323	2.6153	2.1104	0.0873	0.0309
-76.200	-36.573	88.799	0.5827	1.0086	0.7907	0.6262	3.2784	2.3074	0.1005	0.0259
-76.200	-36.573	96.299	0.6319	0.9955	0.7789	0.6199	2.9413	2.8299	0.6656	0.1562
-76.200	-36.573	103.799	0.6811	0.9784	0.7709	0.6026	2.7276	4.6515	-0.0524	-0.0081
-76.200	-36.573	111.299	0.7303	0.9868	0.7696	0.6176	2.4731	1.8906	0.1658	0.0692
-76.200	-36.573	118.799	0.7795	0.9863	0.7608	0.6277	2.6806	1.7920	0.3042	0.1237
-76.200	-36.573	126.299	0.8287	0.9921	0.7586	0.6394	2.3264	1.6751	0.1135	0.0569
-76.200	-36.573	133.800	0.8780	0.9923	0.7507	0.6490	2.5583	1.8629	0.1418	0.0581
-76.200	-36.573	141.300	0.9272	0.9956	0.7455	0.6598	2.7622	1.8692	0.2281	0.0863
-76.200	-36.573	148.800	0.9764	1.0025	0.7467	0.6690	2.1766	2.0767	0.1236	0.0534
-76.200	-36.573	156.300	1.0256	1.0048	0.7473	0.6717	2.8234	2.0855	0.1694	0.0562
-76.200	-36.573	163.800	1.0748	1.0209	0.7595	0.6822	2.7180	1.9921	0.1969	0.0710
-76.200	-36.573	171.300	1.1240	1.0376	0.7721	0.6932	3.4624	1.9105	0.2030	0.0599
-76.200	-36.573	178.800	1.1732	1.0522	0.7888	0.6964	3.1900	1.9583	0.1354	0.0423
-76.200	-36.573	186.300	1.2224	1.0517	0.7993	0.6836	2.9883	3.6771	-0.0959	-0.0170
-76.200	-36.573	193.800	1.2717	1.0562	0.8096	0.6784	2.9765	2.4535	0.2150	0.0575
-76.200	-36.573	201.300	1.3209	1.0523	0.8115	0.6699	2.9223	2.3389	0.3559	0.1017
-76.200	-36.573	208.800	1.3701	1.0432	0.8096	0.6578	3.0546	2.2502	0.2207	0.0627
-76.200	-36.573	216.300	1.4193	1.0410	0.8118	0.6517	2.7118	2.0858	0.3124	0.1079
-76.200	-36.573	223.800	1.4685	1.0381	0.8111	0.6479	3.4741	2.2077	0.3232	0.0823
-76.200	-36.573	231.300	1.5177	1.0378	0.8115	0.6469	3.4136	2.1516	0.6027	0.1603

Station 1- Location 5				S104						
Vref =		71.5411	m/s							
Blade spacing (S) =		152.4	mm							

z(mm)	x(mm)	y(mm)	y/S	W/Vref	U/Vref	V/Vref	Tu	Tv	Re Stress	Corr.
-101.599	-36.573	-76.200	-0.5000	0.9285	0.7197	0.5866	4.9329	5.0958	2.3881	0.1856
-101.599	-36.573	-68.700	-0.4508	0.9447	0.7290	0.6009	4.6084	3.8107	1.2627	0.1405
-101.599	-36.573	-61.200	-0.4016	0.9529	0.7334	0.6084	4.3085	3.4916	0.4087	0.0531
-101.599	-36.573	-53.700	-0.3524	0.9481	0.7282	0.6072	3.5551	3.7436	0.6909	0.1014
-101.599	-36.573	-46.200	-0.3031	0.9372	0.7180	0.6023	3.6525	3.8388	0.4997	0.0696
-101.599	-36.573	-38.700	-0.2539	0.9299	0.7058	0.6055	4.2382	3.6795	0.2794	0.0350
-101.599	-36.573	-31.199	-0.2047	0.9339	0.7050	0.6126	4.0515	3.8249	1.3353	0.1684
-101.599	-36.573	-23.699	-0.1555	0.9192	0.6880	0.6095	3.7718	3.7411	1.1292	0.1564
-101.599	-36.573	-16.199	-0.1063	0.9316	0.6943	0.6211	4.0140	3.8787	1.4160	0.1777
-101.599	-36.573	-8.699	-0.0571	0.9271	0.6821	0.6278	4.5406	3.6377	1.0627	0.1257
-101.599	-36.573	-1.199	-0.0079	0.9394	0.6867	0.6410	3.5182	3.5056	0.3787	0.0600
-101.599	-36.573	6.299	0.0413	0.9524	0.6929	0.6534	3.6317	3.2320	0.3226	0.0537
-101.599	-36.573	13.800	0.0906	0.9722	0.7098	0.6644	3.3682	2.9547	0.1689	0.0332
-101.599	-36.573	21.300	0.1398	0.9871	0.7314	0.6630	3.8693	3.0173	0.3396	0.0568
-101.599	-36.573	28.800	0.1890	0.9907	0.7409	0.6576	3.6498	3.5169	0.3567	0.0543
-101.599	-36.573	36.299	0.2382	0.9948	0.7486	0.6551	4.1775	3.5161	0.9500	0.1264
-101.599	-36.573	43.799	0.2874	0.9947	0.7533	0.6496	3.4187	3.5087	0.3683	0.0600
-101.599	-36.573	51.299	0.3366	0.9839	0.7509	0.6358	3.8701	3.3823	0.4754	0.0710
-101.599	-36.573	58.799	0.3858	0.9891	0.7645	0.6275	3.4603	3.8191	0.3710	0.0548
-101.599	-36.573	66.299	0.4350	0.9652	0.7526	0.6042	3.8773	3.6572	0.8768	0.1208
-101.599	-36.573	73.799	0.4842	0.9676	0.7562	0.6038	4.1097	3.4963	0.8700	0.1183
-101.599	-36.573	81.299	0.5335	0.9647	0.7517	0.6046	3.9020	3.8821	0.4896	0.0631
-101.599	-36.573	88.799	0.5827	0.9600	0.7469	0.6031	3.4832	3.3906	0.2940	0.0486
-101.599	-36.573	96.299	0.6319	0.9579	0.7471	0.5995	3.2022	3.2059	0.3661	0.0697
-101.599	-36.573	103.799	0.6811	0.9440	0.7350	0.5924	3.1144	3.6559	0.1206	0.0207
-101.599	-36.573	111.299	0.7303	0.9323	0.7226	0.5891	3.5925	3.5542	0.2934	0.0449
-101.599	-36.573	118.799	0.7795	0.9261	0.7156	0.5878	4.3637	3.2268	0.3054	0.0424
-101.599	-36.573	126.299	0.8287	0.9308	0.7116	0.6000	3.8486	3.1375	0.6635	0.1074
-101.599	-36.573	133.800	0.8780	0.9467	0.7176	0.6174	4.2673	3.3235	0.2948	0.0406
-101.599	-36.573	141.300	0.9272	0.9538	0.7152	0.6311	3.3013	3.3617	0.6032	0.1062
-101.599	-36.573	148.800	0.9764	0.9554	0.7113	0.6379	3.1392	3.6529	0.1546	0.0263
-101.599	-36.573	156.300	1.0256	0.9599	0.7076	0.6486	3.4226	3.5034	0.4955	0.0807
-101.599	-36.573	163.800	1.0748	0.9650	0.7100	0.6535	3.5714	3.5034	0.1615	0.0252
-101.599	-36.573	171.300	1.1240	0.9753	0.7226	0.6551	3.9370	2.9947	0.1013	0.0168
-101.599	-36.573	178.800	1.1732	0.9919	0.7399	0.6605	4.1778	3.3041	0.6071	0.0859
-101.599	-36.573	186.300	1.2224	1.0038	0.7561	0.6602	3.7668	3.3862	0.4991	0.0765
-101.599	-36.573	193.800	1.2717	1.0030	0.7617	0.6527	3.4480	3.0890	0.4121	0.0756
-101.599	-36.573	201.300	1.3209	0.9947	0.7610	0.6405	4.2717	3.4325	0.7535	0.1004
-101.599	-36.573	208.800	1.3701	0.9866	0.7608	0.6281	3.0818	3.3016	0.3158	0.0606
-101.599	-36.573	216.300	1.4193	0.9717	0.7590	0.6068	3.6028	3.0958	0.0801	0.0140
-101.599	-36.573	223.800	1.4685	0.9582	0.7525	0.5932	3.4375	3.2052	0.1429	0.0253
-101.599	-36.573	231.300	1.5177	0.9591	0.7521	0.5952	3.6772	3.4715	0.4383	0.0671

Wake Surveys

Station 13 centerline survey - Location 1 **1300**

Vref = **71.41** **m/s**

Blade spacing (S) = **152.4** **mm**

z(mm)	x(mm)	y(mm)	y/S	W/Vref	U/Vref	V/Vref	Tu	Tv	Re Stress	Corr.
0.000	146.301	-14.220	-0.0933	0.9013	0.8863	0.1638	1.6355	1.9703	0.2814	0.1712
0.000	146.301	-6.719	-0.0441	0.9016	0.8872	0.1605	1.7527	1.9100	0.2733	0.1601
0.000	146.301	0.780	0.0051	0.8987	0.8851	0.1553	2.6623	1.8850	0.1449	0.0566
0.000	146.301	8.279	0.0543	0.9024	0.8892	0.1541	2.2021	1.9587	0.1741	0.0792
0.000	146.301	15.779	0.1035	0.9120	0.8985	0.1564	1.4415	2.1876	0.1108	0.0689
0.000	146.301	23.280	0.1528	0.9191	0.9046	0.1624	3.1655	2.7166	0.0974	0.0222
0.000	146.301	30.780	0.2020	0.8958	0.8804	0.1657	5.9263	4.4096	0.7317	0.0549
0.000	146.301	38.280	0.2512	0.5523	0.5473	0.0745	20.3699	9.6882	7.2585	0.0721
0.000	146.301	45.780	0.3004	0.1440	0.1429	-0.0174	13.9603	9.4434	1.4015	0.0208
0.000	146.301	53.280	0.3496	0.1703	0.1686	-0.0240	16.2329	8.8342	2.8991	0.0396
0.000	146.301	60.780	0.3988	0.3641	0.3640	0.0074	21.4324	9.2214	2.3040	0.0229
0.000	146.301	68.280	0.4480	0.6156	0.6105	0.0794	20.3332	7.5885	0.6245	0.0079
0.000	146.301	75.780	0.4972	0.8246	0.8181	0.1039	12.8095	5.5325	0.9673	0.0268
0.000	146.301	83.280	0.5465	0.8937	0.8847	0.1260	4.1998	3.8854	-0.1026	-0.0123
0.000	146.301	90.780	0.5957	0.9079	0.8962	0.1453	2.3488	2.5357	0.0998	0.0329
0.000	146.301	98.280	0.6449	0.9064	0.8930	0.1553	1.6248	2.0420	0.2176	0.1286
0.000	146.301	105.780	0.6941	0.9030	0.8884	0.1620	1.5113	1.8399	0.1755	0.1238
0.000	146.301	113.280	0.7433	0.8955	0.8808	0.1619	1.4857	1.7166	0.2613	0.2009
0.000	146.301	120.780	0.7925	0.8924	0.8775	0.1629	1.6383	1.7102	0.2791	0.1953
0.000	146.301	128.280	0.8417	0.8920	0.8777	0.1593	1.9587	1.7384	0.3607	0.2077
0.000	146.301	135.780	0.8909	0.8932	0.8789	0.1594	1.6313	1.7128	0.2017	0.1416
0.000	146.301	143.280	0.9402	0.8916	0.8776	0.1576	1.5471	1.7960	0.1943	0.1371
0.000	146.301	150.780	0.9894	0.8883	0.8750	0.1531	1.4213	1.8097	0.0988	0.0754
0.000	146.301	158.280	1.0386	0.8911	0.8790	0.1459	1.4675	1.8728	0.1904	0.1358
0.000	146.301	165.780	1.0878	0.9034	0.8916	0.1455	1.5200	2.1121	0.3077	0.1880
0.000	146.301	173.280	1.1370	0.9156	0.9022	0.1558	2.5969	2.5352	0.3084	0.0918
0.000	146.301	180.780	1.1862	0.9161	0.9014	0.1636	2.4352	3.5745	0.2158	0.0486
0.000	146.301	188.280	1.2354	0.7684	0.7563	0.1358	15.8339	7.4194	9.4500	0.1577
0.000	146.301	195.780	1.2846	0.1990	0.1989	-0.0055	16.2007	9.8226	5.1450	0.0634
0.000	146.301	203.280	1.3339	0.1291	0.1280	-0.0172	14.7920	9.1686	2.0088	0.0290
0.000	146.301	210.780	1.3831	0.2927	0.2927	-0.0014	20.0342	9.6029	-0.2245	-0.0023
0.000	146.301	218.280	1.4323	0.5770	0.5730	0.0682	22.2688	8.5238	7.2680	0.0751
0.000	146.301	225.780	1.4815	0.8108	0.8058	0.0902	12.9270	5.9478	-0.9891	-0.0252
0.000	146.301	233.280	1.5307	0.8844	0.8771	0.1134	4.9887	4.2922	-0.8002	-0.0733
0.000	146.301	240.780	1.5799	0.8977	0.8882	0.1306	3.2238	2.9784	-0.0081	-0.0017

Station 13 - Location 2					1301					
Vref =				71.755	m/s					
Blade spacing (S) =				152.4	mm					

z(mm)	x(mm)	y(mm)	y/S	W/Vref	U/Vref	V/Vref	Tu	Tv	Re Stress	Corr.
-25.399	146.301	-14.220	-0.0933	0.9119	0.8956	0.1714	2.2392	2.2692	0.4485	0.1714
-25.399	146.301	-6.719	-0.0441	0.9037	0.8878	0.1685	3.1198	2.1557	0.6104	0.1763
-25.399	146.301	0.780	0.0051	0.9038	0.8891	0.1627	1.5467	2.0346	0.4834	0.2983
-25.399	146.301	8.279	0.0543	0.9054	0.8903	0.1647	2.9284	2.1885	0.4660	0.1412
-25.399	146.301	15.779	0.1035	0.9146	0.9003	0.1612	1.4335	2.3359	0.2238	0.1298
-25.399	146.301	23.280	0.1528	0.9197	0.9046	0.1657	2.4816	2.8963	0.2716	0.0734
-25.399	146.301	30.780	0.2020	0.9040	0.8885	0.1671	4.5656	3.9724	-0.4545	-0.0487
-25.399	146.301	38.280	0.2512	0.5125	0.5067	0.0768	18.8881	9.9154	15.0999	0.1566
-25.399	146.301	45.780	0.3004	0.0599	0.0560	-0.0214	14.0847	9.0371	2.7270	0.0416
-25.399	146.301	53.280	0.3496	0.0348	0.0328	-0.0115	14.1403	9.5103	-1.1377	-0.0164
-25.399	146.301	60.780	0.3988	0.2209	0.2206	0.0120	20.4351	10.0355	5.6064	0.0531
-25.399	146.301	68.280	0.4480	0.5224	0.5172	0.0735	22.5191	8.5080	8.7986	0.0892
-25.399	146.301	75.780	0.4972	0.7656	0.7565	0.1172	17.7292	6.2101	0.1353	0.0024
-25.399	146.301	83.280	0.5465	0.8849	0.8727	0.1466	7.6336	4.3066	-0.2922	-0.0173
-25.399	146.301	90.780	0.5957	0.9123	0.8981	0.1605	2.0606	2.6067	-0.0042	-0.0015
-25.399	146.301	98.280	0.6449	0.9130	0.8977	0.1665	1.4966	1.9433	0.1763	0.1177
-25.399	146.301	105.780	0.6941	0.9097	0.8934	0.1717	2.5878	1.7031	0.1605	0.0707
-25.399	146.301	113.280	0.7433	0.9082	0.8911	0.1756	1.4260	1.5700	0.1695	0.1471
-25.399	146.301	120.780	0.7925	0.9078	0.8908	0.1751	2.7380	1.5657	0.2443	0.1107
-25.399	146.301	128.280	0.8417	0.9130	0.8954	0.1785	2.9259	1.7772	0.4962	0.1853
-25.399	146.301	135.780	0.8909	0.9147	0.8968	0.1800	2.4083	1.8528	0.3790	0.1650
-25.399	146.301	143.280	0.9402	0.9091	0.8919	0.1761	3.5258	2.5335	0.5652	0.1229
-25.399	146.301	150.780	0.9894	0.9064	0.8898	0.1729	1.3676	1.9641	0.4406	0.3186
-25.399	146.301	158.280	1.0386	0.9069	0.8908	0.1703	2.8777	1.9442	0.4132	0.1434
-25.399	146.301	165.780	1.0878	0.9115	0.8965	0.1642	2.3071	1.8373	0.0337	0.0154
-25.399	146.301	173.280	1.1370	0.9220	0.9077	0.1621	3.1149	2.3379	0.1747	0.0466
-25.399	146.301	180.780	1.1862	0.9159	0.9011	0.1637	4.2319	3.5916	-0.0602	-0.0077
-25.399	146.301	188.280	1.2354	0.6940	0.6861	0.1043	17.6599	8.2394	8.1393	0.1086
-25.399	146.301	195.780	1.2846	0.1400	0.1397	-0.0104	17.4010	9.8008	-0.5897	-0.0067
-25.399	146.301	203.280	1.3339	0.0308	0.0302	0.0060	13.0147	9.8548	4.0432	0.0612
-25.399	146.301	210.780	1.3831	0.1958	0.1958	0.0049	21.2633	9.4994	4.7008	0.0452
-25.399	146.301	218.280	1.4323	0.4552	0.4512	0.0602	22.5693	9.5957	5.2514	0.0471
-25.399	146.301	225.780	1.4815	0.7294	0.7218	0.1055	19.2231	7.1065	2.7609	0.0393
-25.399	146.301	233.280	1.5307	0.8643	0.8537	0.1350	10.1743	4.9724	0.6351	0.0244
-25.399	146.301	240.780	1.5799	0.9086	0.8953	0.1549	3.2760	3.1282	-0.0834	-0.0158

Station 13 - Location 3					1302					
Vref =			71.956	m/s						
Blade spacing (S) =			152.4	mm						
z(mm)	**x(mm)**	**y(mm)**	**y/S**	**W/Vref**	**U/Vref**	**V/Vref**	**Tu**	**Tv**	**Re Stress**	**Corr.**
-50.799	146.301	-14.220	-0.0933	0.9072	0.8892	0.1799	2.4720	2.6459	0.7403	0.2186
-50.799	146.301	-6.719	-0.0441	0.8988	0.8818	0.1741	2.9018	2.5676	0.8124	0.2106
-50.799	146.301	0.780	0.0051	0.8975	0.8811	0.1709	2.9473	2.4599	0.3901	0.1039
-50.799	146.301	8.279	0.0543	0.8990	0.8835	0.1662	1.4500	2.4064	0.3178	0.1759
-50.799	146.301	15.779	0.1035	0.9024	0.8862	0.1702	2.9830	2.3216	0.1686	0.0470
-50.799	146.301	23.280	0.1528	0.9171	0.9001	0.1756	4.1226	2.4660	0.0913	0.0173
-50.799	146.301	30.780	0.2020	0.9247	0.9018	0.2047	3.2423	3.7897	-0.2329	-0.0366
-50.799	146.301	38.280	0.2512	0.7110	0.6434	0.3024	17.6366	12.1136	12.2707	0.1109
-50.799	146.301	45.780	0.3004	0.2786	0.1505	0.2345	16.0719	17.9243	7.1983	0.0483
-50.799	146.301	53.280	0.3496	0.2579	0.2157	0.1414	20.8486	14.1007	-14.1457	-0.0929
-50.799	146.301	60.780	0.3988	0.5016	0.4691	0.1777	23.8804	13.3562	-5.3597	-0.0325
-50.799	146.301	68.280	0.4480	0.7654	0.7542	0.1307	17.5618	10.8803	-15.8114	-0.1598
-50.799	146.301	75.780	0.4972	0.8899	0.8813	0.1236	6.6925	6.3367	-2.4120	-0.1098
-50.799	146.301	83.280	0.5465	0.9155	0.9046	0.1415	2.5120	3.2484	-0.1585	-0.0375
-50.799	146.301	90.780	0.5957	0.9151	0.9024	0.1518	2.3347	1.9722	0.1499	0.0629
-50.799	146.301	98.280	0.6449	0.9158	0.9003	0.1677	1.3988	1.7963	0.1149	0.0883
-50.799	146.301	105.780	0.6941	0.9112	0.8955	0.1684	1.4237	1.6549	0.2308	0.1892
-50.799	146.301	113.280	0.7433	0.9091	0.8924	0.1734	2.8674	1.6140	0.0377	0.0157
-50.799	146.301	120.780	0.7925	0.9104	0.8921	0.1815	1.4756	1.7842	0.1903	0.1396
-50.799	146.301	128.280	0.8417	0.9115	0.8922	0.1866	1.5522	1.6986	0.2846	0.2085
-50.799	146.301	135.780	0.8909	0.9131	0.8930	0.1902	1.5214	1.7940	0.2403	0.1700
-50.799	146.301	143.280	0.9402	0.9123	0.8924	0.1891	1.3740	2.0227	0.2926	0.2033
-50.799	146.301	150.780	0.9894	0.9071	0.8888	0.1811	3.5605	1.9963	0.3335	0.0906
-50.799	146.301	158.280	1.0386	0.8887	0.8733	0.1647	3.1946	2.1480	0.5388	0.1516
-50.799	146.301	165.780	1.0878	0.8998	0.8841	0.1669	2.8002	2.0993	0.1977	0.0649
-50.799	146.301	173.280	1.1370	0.9119	0.8950	0.1748	2.1208	2.2140	0.1912	0.0786
-50.799	146.301	180.780	1.1862	0.9177	0.8964	0.1966	3.4379	3.0158	-0.0222	-0.0041
-50.799	146.301	188.280	1.2354	0.8395	0.7965	0.2652	13.3134	8.2016	-0.6038	-0.0107
-50.799	146.301	195.780	1.2846	0.3549	0.2517	0.2502	17.3358	17.4119	8.0553	0.0515
-50.799	146.301	203.280	1.3339	0.2055	0.1464	0.1441	19.0167	15.3213	8.3049	0.0551
-50.799	146.301	210.780	1.3831	0.4070	0.3782	0.1505	22.6656	13.7722	-6.9478	-0.0430
-50.799	146.301	218.280	1.4323	0.6765	0.6540	0.1732	21.2376	12.6544	-19.6581	-0.1413
-50.799	146.301	225.780	1.4815	0.8485	0.8359	0.1460	11.4750	9.5566	-11.7578	-0.2071
-50.799	146.301	233.280	1.5307	0.9046	0.8940	0.1382	4.0984	4.2878	-1.7143	-0.1884
-50.799	146.301	240.780	1.5799	0.9112	0.8996	0.1450	3.9504	2.4667	0.0648	0.0129

Station 13 - Location 4					1303					
Vref =		71.9899	m/s							
Blade spacing (S) =		152.4	mm							
z(mm)	x(mm)	y(mm)	y/S	W/Vref	U/Vref	V/Vref	Tu	Tv	Re Stress	Corr.
-76.200	146.301	-14.220	-0.0933	0.8621	0.8482	0.1543	4.1519	3.2009	1.4436	0.2096
-76.200	146.301	-6.719	-0.0441	0.8684	0.8533	0.1616	2.9273	2.8403	1.0833	0.2514
-76.200	146.301	0.780	0.0051	0.8759	0.8611	0.1601	2.3483	2.6998	0.4894	0.1490
-76.200	146.301	8.279	0.0543	0.8807	0.8658	0.1611	2.8929	2.4481	0.4952	0.1349
-76.200	146.301	15.779	0.1035	0.8917	0.8763	0.1647	1.6543	2.2925	0.2564	0.1305
-76.200	146.301	23.280	0.1528	0.8986	0.8830	0.1665	2.7839	2.5155	0.3290	0.0906
-76.200	146.301	30.780	0.2020	0.8925	0.8755	0.1736	5.1826	3.8169	0.3623	0.0353
-76.200	146.301	38.280	0.2512	0.6622	0.6036	0.2724	16.9820	13.1172	6.5465	0.0567
-76.200	146.301	45.780	0.3004	0.2639	0.2028	0.1688	16.8504	16.3138	7.7849	0.0546
-76.200	146.301	53.280	0.3496	0.6340	0.6300	0.0709	19.8713	9.8202	-4.7646	-0.0471
-76.200	146.301	60.780	0.3988	0.8827	0.8811	0.0528	5.3202	3.1860	-0.6834	-0.0778
-76.200	146.301	68.280	0.4480	0.8971	0.8946	0.0674	3.5879	2.2941	0.0558	0.0131
-76.200	146.301	75.780	0.4972	0.8934	0.8880	0.0981	4.0078	2.4404	0.1412	0.0279
-76.200	146.301	83.280	0.5465	0.8913	0.8831	0.1208	3.6091	2.5445	0.8182	0.1719
-76.200	146.301	90.780	0.5957	0.8887	0.8779	0.1377	2.9775	2.4325	0.5406	0.1440
-76.200	146.301	98.280	0.6449	0.8927	0.8800	0.1503	2.4143	2.1926	0.4965	0.1810
-76.200	146.301	105.780	0.6941	0.8970	0.8821	0.1626	3.2468	2.0401	0.1894	0.0552
-76.200	146.301	113.280	0.7433	0.9027	0.8870	0.1677	3.4867	1.9977	0.4447	0.1232
-76.200	146.301	120.780	0.7925	0.8926	0.8769	0.1667	1.9640	2.2810	0.5663	0.2439
-76.200	146.301	128.280	0.8417	0.8792	0.8635	0.1654	3.8982	2.7149	0.6125	0.1117
-76.200	146.301	135.780	0.8909	0.8690	0.8541	0.1607	3.4478	2.6151	0.8136	0.1741
-76.200	146.301	143.280	0.9402	0.8763	0.8620	0.1578	2.8142	2.2570	0.4368	0.1327
-76.200	146.301	150.780	0.9894	0.8853	0.8712	0.1573	3.9559	2.0876	0.1060	0.0248
-76.200	146.301	158.280	1.0386	0.8844	0.8705	0.1562	6.6856	2.3293	0.6998	0.0867
-76.200	146.301	165.780	1.0878	0.8832	0.8715	0.1436	5.2193	2.3945	0.3320	0.0513
-76.200	146.301	173.280	1.1370	0.8874	0.8754	0.1459	3.6986	2.5692	0.5580	0.1133
-76.200	146.301	180.780	1.1862	0.8923	0.8784	0.1570	2.2188	3.2142	0.2450	0.0663
-76.200	146.301	188.280	1.2354	0.8062	0.7792	0.2070	11.9835	8.9261	-4.4951	-0.0811
-76.200	146.301	195.780	1.2846	0.3345	0.2260	0.2465	15.0281	18.0470	4.1627	0.0296
-76.200	146.301	203.280	1.3339	0.4901	0.4762	0.1158	20.5048	11.2886	-4.1697	-0.0348
-76.200	146.301	210.780	1.3831	0.8564	0.8545	0.0566	8.4152	5.8766	-2.9941	-0.1168
-76.200	146.301	218.280	1.4323	0.8884	0.8868	0.0538	3.5065	2.0789	0.0998	0.0264
-76.200	146.301	225.780	1.4815	0.8902	0.8863	0.0829	2.5128	1.9820	-0.0036	-0.0014
-76.200	146.301	233.280	1.5307	0.8901	0.8833	0.1105	2.5210	1.9458	0.2915	0.1147
-76.200	146.301	240.780	1.5799	0.8892	0.8795	0.1306	1.8230	2.0419	0.2466	0.1278

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APPENDIX F : CFD ANALYSIS RESULTS

'swift.in' sample input namelist (Test Case #5)

```
'GELDER CONTROLLED-DIFFUSION CASCADE'

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&nl3 ibcin=1 ibcex=1 isymt=0 ires=1
iresti=1 iresto=1 iqin=0 &end
&nl4 expt=0.0 prat=0.978 ga=1.4
om=0.000000 igeom=0 &end
&nl5 ilt=5 tw=1.00 renr=2.83e6 prnr=.7 prtr=.9 vispwr=.666666
cmutm=0. jedge=40 kedgh=70
hrough=4. tintens=0.02 tlength=3e-5 itur=2
iltin=2 dblh=0.6 dblt=0.60 &end
&nl6 mioe=3 oar=0
&end

row  P0    Mx      My      Mz     T0
 0   1.00  0.17336 0.13545 0.000  1.0000
 1   0.98  0.14000 0.00000 0.000  1.0000
```
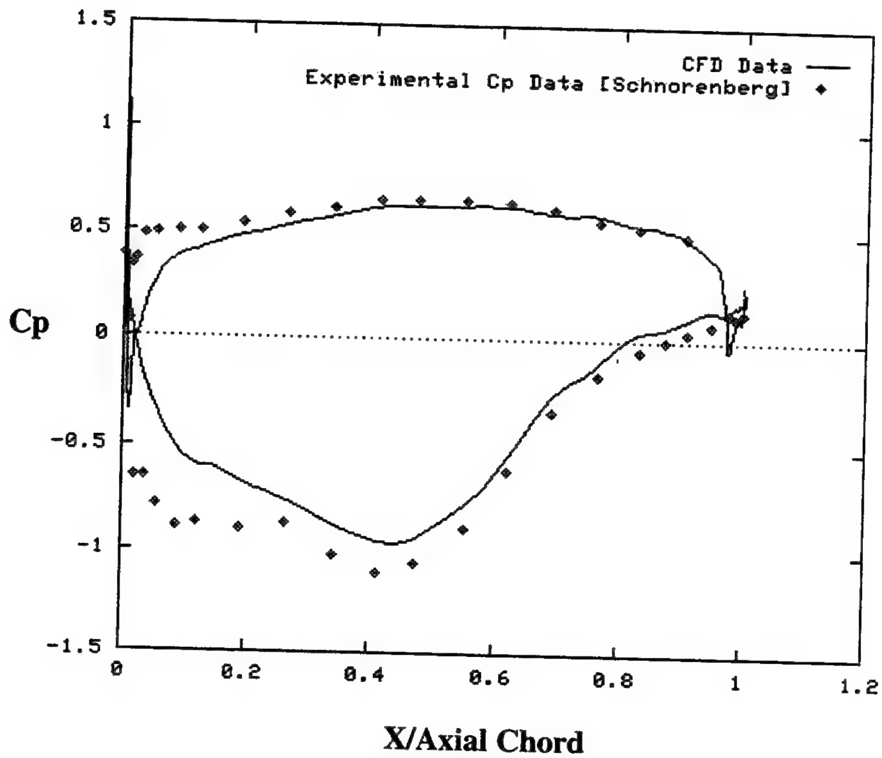
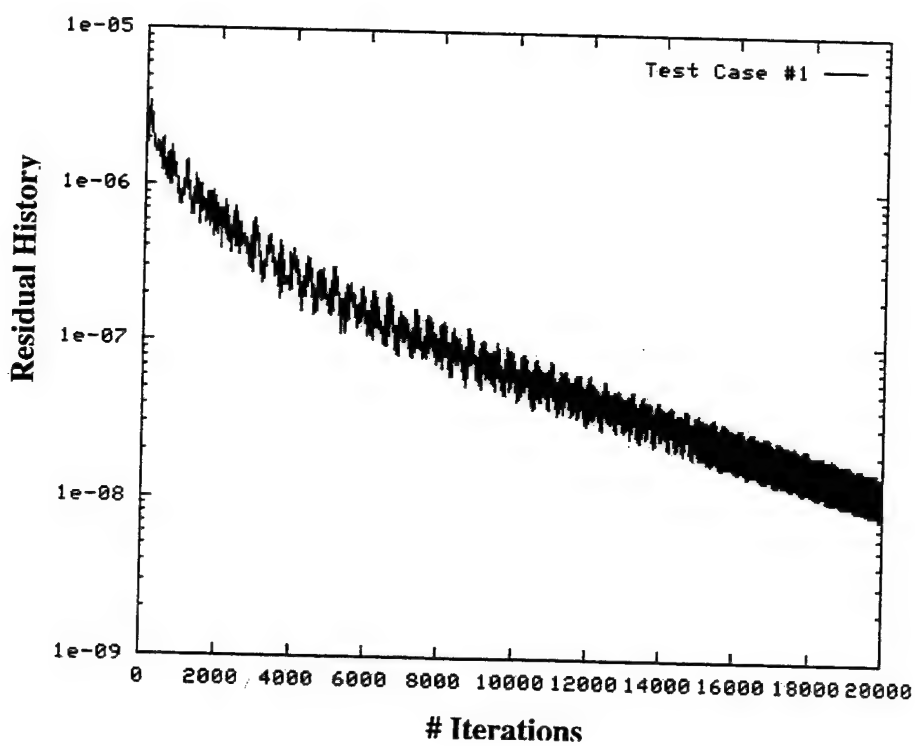
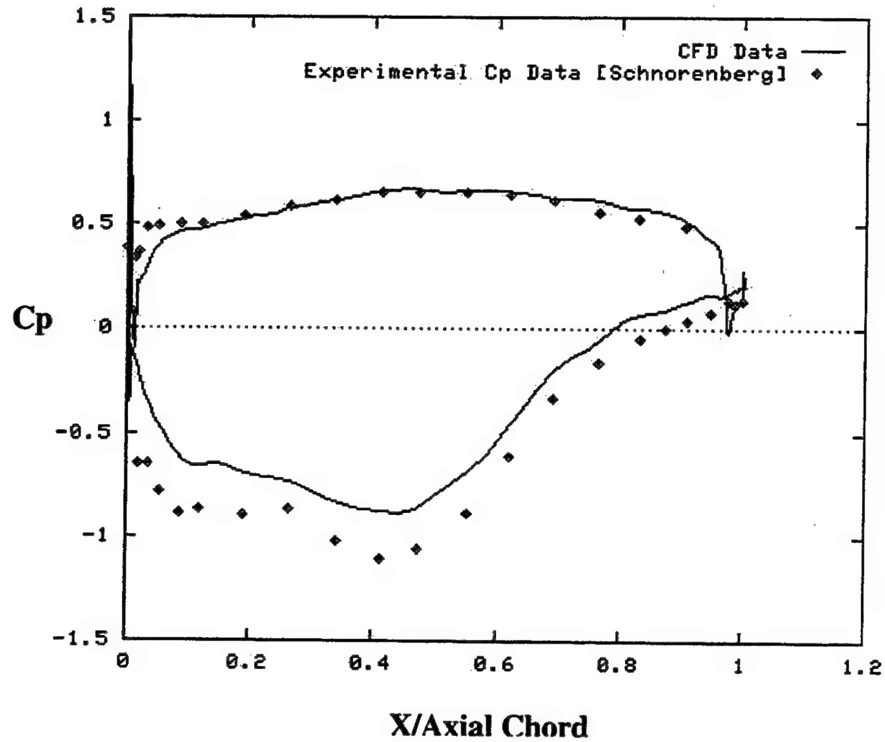
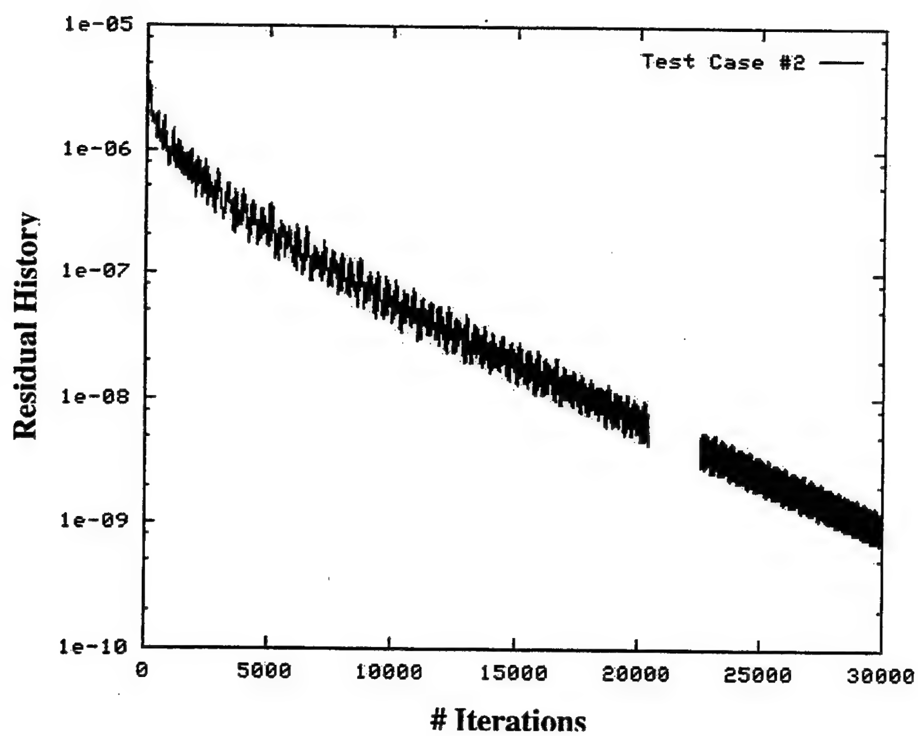

Test Case #1 - Cp Profile and Residual History



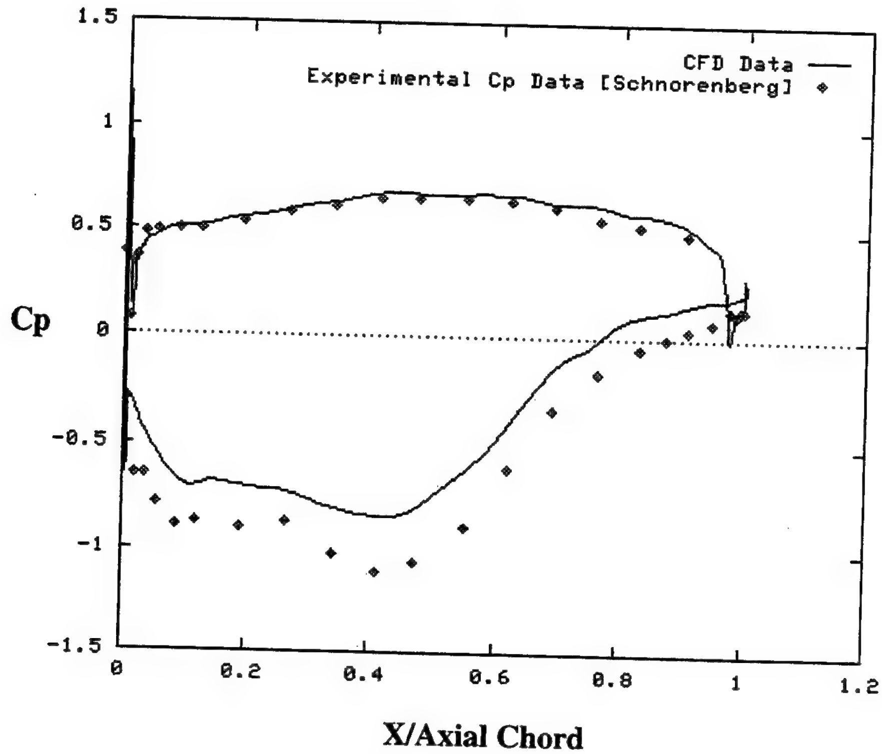


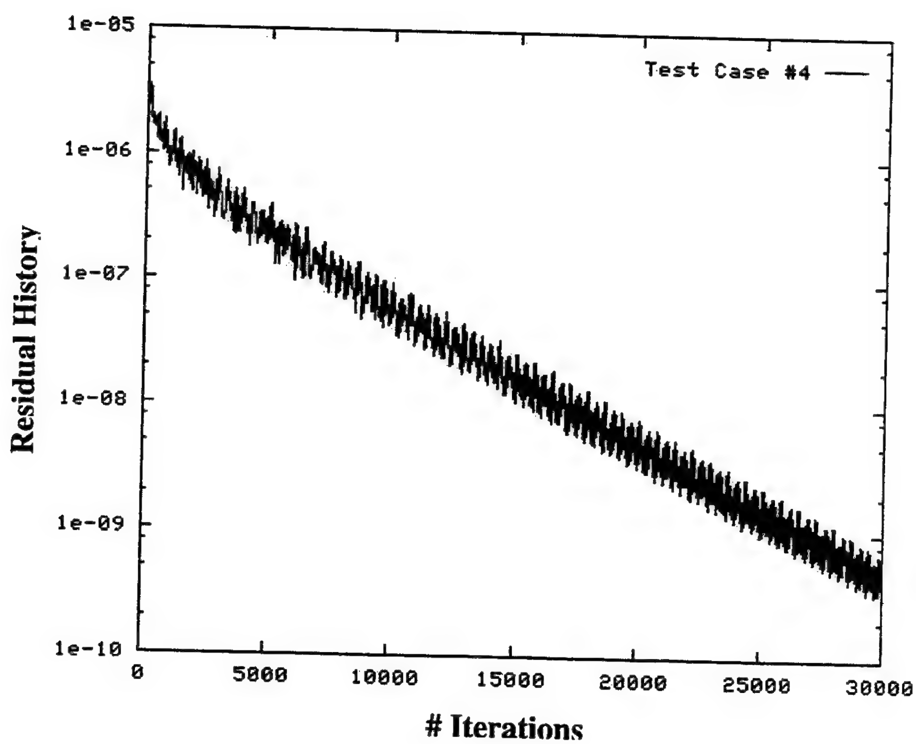
Test Case #2 - Cp Profile and Residual History



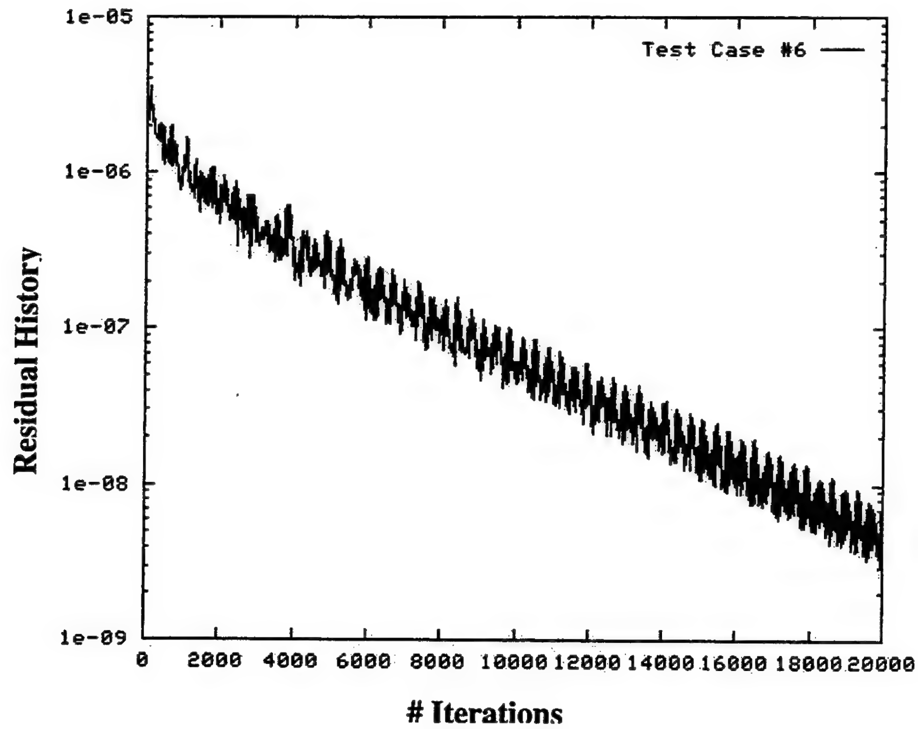


Test Case # 4 - Cp Profile and Residual History

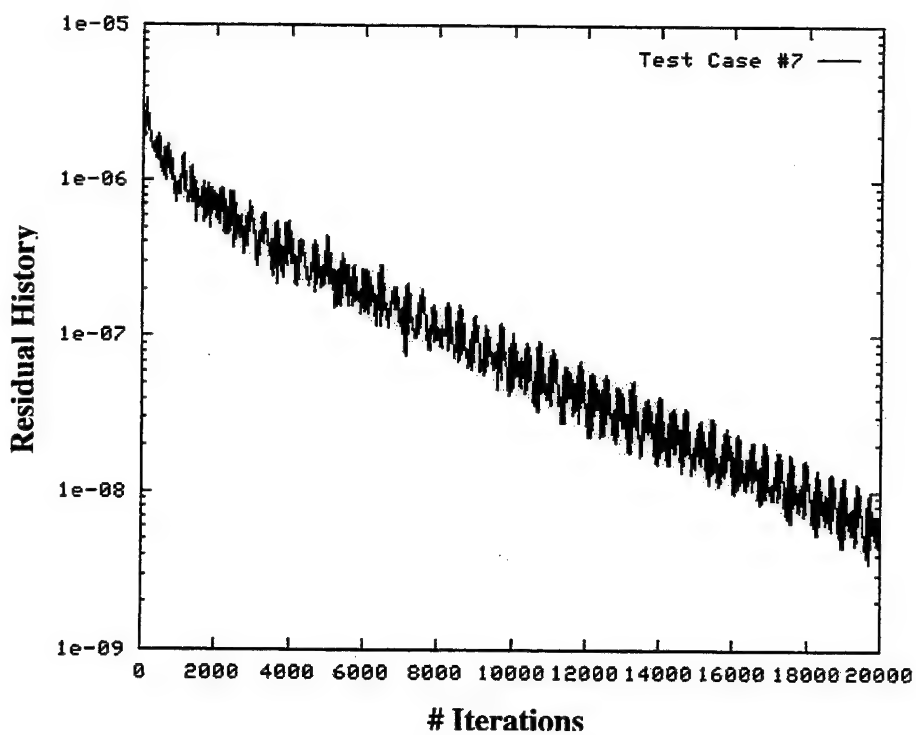




Test Case #6 - Residual History



Test Case #7 - Residual History



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